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LOWER CRETACEOUS (COMANCHE) ROCKS OF SOUTHEASTERN OKLAHOMA AND SOUTHWESTERN ARKANSAS[1]

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ABSTRACT

The Lower Cretaceous (Comanche) rocks of southeastern Oklahoma and southwestern Arkansas rest upon rocks of many different ages ranging from pre-Cambrian to Permian, but the floor they lie upon is a remarkably uniform plane with minor irregularities in spite of the folds and faults in the Paleozoic rocks. The floor represents a part of the Ouachita peneplain that was tilted slightly southward and submerged by the Cretaceous sea.

A pronounced unconformity, though less striking than the one at the base of the Lower Cretaceous, separates the rocks of this series from the overlying Upper Cretaceous series. Its plane truncates all the several formations of the Lower Cretaceous, the youngest formations in Oklahoma, and the oldest in Arkansas.

The Trinity formation, the basal unit of the Lower Cretaceous, contains beds in Arkansas that do not extend westward far into Oklahoma, owing to a westward overlap of the upper part of the Trinity over the lower part of the formation. The Trinity of Oklahoma is thus for the most part younger than the Trinity of Arkansas.

Two contrasting relations thus exist in the Cretaceous of southeastern Oklahoma and southwestern Arkansas—(1) a westward overlap in the basal formation (Trinity) of the Lower Cretaceous and (2) an eastward overlap of the Upper Cretaceous across the truncated edges of the Lower Cretaceous. The westward overlap in Lower Cretaceous time was caused by a downwarping of the Texas-Oklahoma embayment that lies between the Llano and Ouachita uplifts. The eastward overlap in Upper Cretaceous time was evidently caused by a regional movement that formed the Mississippi embayment.

GENERAL AGE RELATIONS OF LOWER CRETACEOUS ROCKS

The rocks of Lower Cretaceous (Comanche) age of southeastern Oklahoma and southwestern Arkansas are exposed in a narrow belt extending in a westerly direction from Arkansas into and across southeastern Oklahoma and thence southwestward into Texas (Fig. 1). They are in general slightly inclined toward the Gulf, the dip attaining a maximum of more than 100 feet to the mile. They are separated from the underlying rocks by a profound unconformity whose plane truncates folded and faulted rocks of many ages—Permian, Pennsylvanian, Mississippian, Devonian, Silurian, Ordovician, Cambrian, and pre-Cambrian. Also they are sepa-

[1] Manuscript received by the editor, February 10, 1927. Published by permission of the director of the United States Geological Survey.

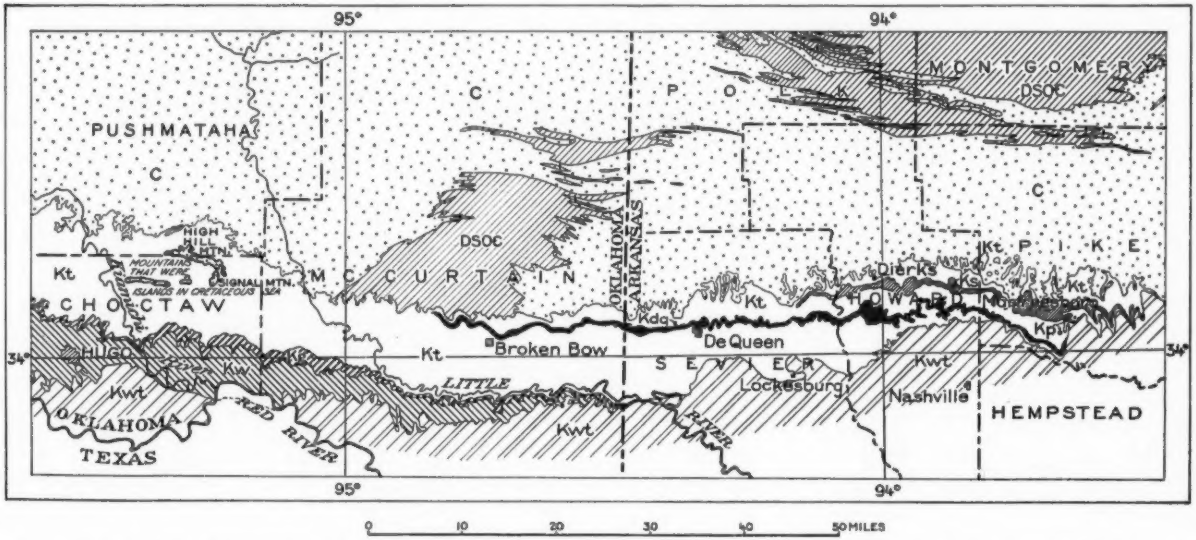

FIG. 1.—Map of parts of southeastern Oklahoma and southwestern Arkansas, showing the distribution of the Lower Cretaceous (Comanche) rocks

Upper Cretaceous
Kwt, Tokio and Woodbine formations.
Peridotite, Kp, that was intruded in early Upper Cretaceous time.
Lower Cretaceous
Kw, Washita group.
Kg, Goodland limestone.
Kt, Trinity formation.
Kdq, De Queen limestone member.
Ks, Dierks limestone lentil.
Carboniferous
C, Atoka formation, Jackfork sandstone, and Stanley shale.
Devonian, Silurian, Ordovician, and Cambrian, DSOC

rated from the superjacent Upper Cretaceous rocks by an angular unconformity whose plane truncates all the several formations of Lower Cretaceous age, the youngest formations in Oklahoma and the oldest in Arkansas. Furthermore, the basal unit—the Trinity formation—contains beds in Arkansas that do not extend westward far into Oklahoma, owing to a westward overlap of the upper part of the Trinity over the lower part of the formation. The Trinity of Oklahoma is thus for the most part younger than the Trinity of Arkansas. The present paper describes briefly the unconformities that limit the Lower Cretaceous both above and below, and also describes the westward overlap in the Trinity. These relations are graphically represented in the accompanying structure section (Fig. 2).

As the unconformity at the base of the Lower Cretaceous is well known, being described in many reports, only a few of the features connected with it are mentioned, but the unconformity at the top, although known for many years, has not been studied by detailed mapping of adjacent formations until recent years.[1]

[1] Some of the reports that describe the Lower Cretaceous rocks of Arkansas and Oklahoma are as follows:

R. T. Hill, "The Neozoic Geology of Southwestern Arkansas," *Arkansas Geol. Survey Ann. Rept. for 1888*, Vol. 2, 1888.

R. T. Hill, "The Comanche Series of the Texas-Arkansas Region," *Bull. Geol. Soc. America*, Vol. 2 (1891), pp. 503–28.

R. T. Hill, "Geology of Parts of Texas, Indian Territory, and Arkansas Adjacent to Red River," *ibid.*, Vol. 5 (1894), pp. 297–338.

R. T. Hill, "Geography and Geology of the Black and Grand Prairies, Texas," *U. S. Geol. Survey Twenty-first Ann. Rept.*, Part 7, 1901.

J. A. Taff, *U. S. Geol. Survey Geol. Atlas, Atoka Folio*, No. 79, 1902.

J. A. Taff, *ibid., Tishomingo Folio*, No. 98, 1903.

A. C. Veatch, "Geology and Underground Water Resources of Northern Louisiana and Southern Arkansas," *U. S. Geol. Survey Prof. Paper 46*, 1906.

H. D. Miser and A. H. Purdue, "Gravel Deposits of the Caddo Gap and De Queen Quadrangles, Arkansas," *U. S. Geol. Survey Bull. 690* (1918), pp. 15–29.

H. D. Miser and A. H. Purdue, "Asphalt Deposits and Oil Conditions in Southwestern Arkansas," *U. S. Geol. Survey Bull. 691* (1918), pp. 271–92.

L. W. Stephenson, "A Contribution to the Geology of Northeastern Texas and Southern Oklahoma," *U. S. Geol. Survey Prof. Paper 120* (1919), pp. 129–63.

O. B. Hopkins, Sidney Powers, and H. M. Robinson, "The Structure of the Madill-Denison Area, Oklahoma and Texas, with Notes on Oil and Gas Development," *U. S. Geol. Survey Bull. 736* (1922), pp. 1–34.

C. W. Honess, "Geology of the Southern Ouachita Mountains of Oklahoma," *Oklahoma Geol. Survey Bull. 32* (1923), pp. 202–9, 263–66.

F. M. Bullard, "Geology of Love County, Oklahoma," *Oklahoma Geol. Survey Bull. 33*, 1925.

F. M. Bullard, "Geology of Marshall County, Oklahoma," *Oklahoma Geol. Survey Bull. 39*, 1926.

C. H. Dane, "Oil-bearing Formations of Southwestern Arkansas," *U. S. Geol. Survey Press Notice 8823*, 1926.

H. D. Miser, "Geologic Map of Oklahoma," *U. S. Geol. Survey*, 1926.

H. D. Miser and A. H. Purdue, "Geology of the De Queen and Caddo Gap Quadrangles, Arkansas and Oklahoma," *U. S. Geol. Survey Bull.* (in preparation).

L. W. Stephenson, "Notes on the Stratigraphy of the Upper Cretaceous Formations of Texas and Arkansas," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 11 (1927), pp. 1–17.

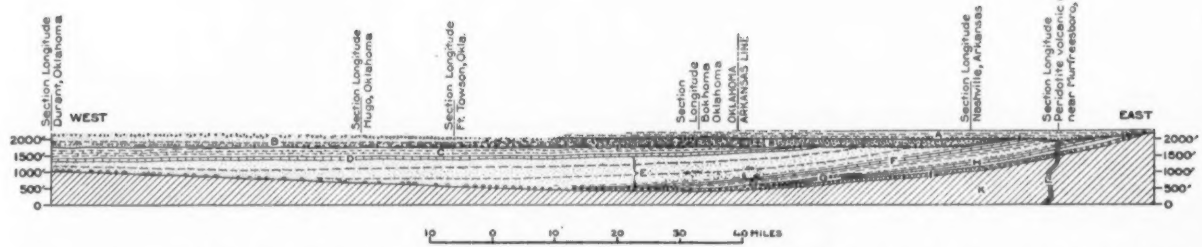

FIG. 2.—Generalized diagrammatic east-west structure section through parts of southeastern Oklahoma and southwestern Arkansas, showing the westward overlap in the Trinity formation (E) and the unconformity at the top of the Lower Cretaceous (Comanche). Vertical scale in feet.

A. Tokio formation, Upper Cretaceous; contains some water-laid volcanic tuff (indicated by triangular patterns).
B. Woodbine formation, Upper Cretaceous; contains much water-laid volcanic tuff.
C. Washita group, Lower Cretaceous.
D. Goodland limestone, Lower Cretaceous.
E. Trinity formation, Lower Cretaceous.
F. De Queen limestone member.
G. Ultima Thule gravel lentil.
H. Dierks limestone lentil.
I. Pike gravel member.
K. Devonian, Silurian, Ordovician, Cambrian, and pre-Cambrian
L. Peridotite that was intruded in early Upper Cretaceous time.

Also the overlap in the Trinity was not definitely recognized until recent years, although R. T. Hill[1] expressed many years ago the opinion that the limestone-bearing part of the Trinity of Arkansas is older than the thick bed of sand that constitutes the bulk of the Trinity of Oklahoma.

FIELD STUDIES FOR THE PRESENT PAPER

The conclusions of this paper are based on studies that were carried on in the De Queen and Caddo Gap quadrangles, Arkansas and Oklahoma, by the late A. H. Purdue, R. D. Mesler, and the writer through a period of many years beginning in 1908 and that were extended westward by the writer into McCurtain and Choctaw counties, Oklahoma, in 1916 and 1923.

UNCONFORMITY AT BASE OF LOWER CRETACEOUS ROCKS

Although the rocks of Lower Cretaceous age rest upon rocks of many different ages ranging, as previously stated, from pre-Cambrian to Permian, the floor they lie upon is a remarkably uniform plane with minor irregularities, in spite of the folds and faults in the Paleozoic rocks. The floor represents a part of the Ouachita peneplain that was tilted slightly southward and submerged by the Cretaceous sea. Its dip ranges from 80 feet to more than 100 feet to the mile in southwestern Arkansas, but decreases toward the west in Oklahoma.

The irregularities of the floor consist of a few hills and ridges that are produced mostly by upturned edges of the hard steeply-dipping Jackfork sandstone, 6,000 feet thick, of Carboniferous age. Such hills and ridges stood up as promontories and islands in the Lower Cretaceous sea. The most conspicuous ones, some of which have been described by Honess,[2] are High Hill, Signal, and adjacent mountains in Choctaw and Pushmataha counties (Fig. 1). They rise 250 feet above the surface of the adjoining areas of Trinity sand that entirely surround them. They once rose perhaps 500 feet above the Ouachita peneplain and when that part of the peneplain was submerged they dotted the Lower Cretaceous sea as steep rocky islands.

The basal formation of the Lower Cretaceous in the two states is the Trinity formation which contains a diversity of kinds of rocks—sand, clay, gravel, and limestone—but consists mostly of sand. It has at the base a thick persistent bed of gravel in Arkansas and a less persistent bed of gravel in Oklahoma. Owing to the great variety of rocks from which streams carried débris into the Trinity sea, the basal gravel consists mostly of pebbles of different kinds of rocks at different places, dependent upon their source. The gravel in Arkansas, which is known as the Pike gravel member, ranges in thickness from a feather edge to 100 feet, being thickest toward the east. It consists mostly of pebbles of novaculite of many

[1] R. T. Hill, "The Comanche Series of the Texas-Arkansas Region," *Bull. Geol. Soc. America*, Vol. 2 (1891), p. 511.

[2] C. W. Honess, "Geology of the Southern Ouachita Mountains of Oklahoma," *Okla. Geol. Survey Bull. 32* (1923), pp. 204 and 264.

colors that had their source in the extensive exposures of Arkansas novaculite in the west-central part of the state, but the lower few feet contains well-rounded boulders of sandstone that have been derived from the Carboniferous rocks upon which the Trinity rests in Arkansas.

The Pike gravel member is not distinguishable west of the Oklahoma-Arkansas line from a younger gravel (Ultima Thule gravel lentil) which approaches nearer and nearer the base of the Trinity toward the west and which finally merges with the Pike member near the state line. These overlapping relations of the Ultima Thule gravel lentil over the beds of clay and sand separating it from the Pike gravel suggest that it may entirely overlap the Pike gravel near the state line; if so, the basal gravel in McCurtain County is of the same age as the Ultima Thule gravel.

The proportion of quartz pebbles in the Pike and Ultima Thule gravels increases westward from a point north of De Queen, Arkansas, and they constitute a large part of the basal gravel of the Trinity, in McCurtain County, Oklahoma. The quartz pebbles are derived, as pointed out by Honess,[1] from the wide and plentiful quartz veins and quartz-orthoclase pegmatites that cut the Carboniferous and older Paleozoic rocks in northern McCurtain County. Furthermore, the novaculite pebbles in the basal gravel resemble in character the Arkansas novaculite in the exposures in the northern part of that county and probably had their source there. Not more than a small proportion of them came from the exposures of the formation in Arkansas.

High Hill, Signal, and other mountains of sandstone within the Coastal Plain in northeastern Choctaw and southeastern Pushmataha counties, Oklahoma, which were islands in the Cretaceous sea, are surrounded in part, according to Honess,[2] by large blocks of sandstone that collected at the base of sea cliffs in Cretaceous time.

Between McCurtain County and the vicinity of Atoka the basal bed of gravel is sporadic in occurrence and is composed largely of boulders and cobbles of sandstone which came from the adjacent areas of sandstone of Carboniferous age.

Between Atoka and Red River the Trinity rests upon rocks of many different kinds and ages, including the pre-Carboniferous rocks of the Arbuckle Mountains. A basal conglomerate, which attains a thickness of 50 feet, is present at some places and is composed of materials differing according to their source. Where the Trinity overlies granite the basal part of the formation is composed chiefly of sand and quartz grit derived from the disintegrated granite.[3] Where the lower part of the Trinity is near the large exposures of limestone in the Arbuckle Mountains it is composed of a very coarse limestone conglomerate cemented in a matrix of chalky

[1] *Op. cit.*, pp. 203–4.

[2] *Ibid.*

[3] J. A. Taff, *U. S. Geol. Survey Geol. Atlas, Atoka Folio*, No. 79 (1902), p. 5, and *Tishomingo Folio*, No. 98 (1903), p. 6.

white lime and grit.[1] The materials composing the conglomerate range from boulders a foot in diameter to small pebbles, and have originated chiefly from the Cambrian and Ordovician limestones of the Arbuckle Mountain region.

OVERLAP IN TRINITY FORMATION

The overlap of the upper part of the Trinity formation over the lower part toward the west is shown by the areal distribution of the different beds of rock in the formation. The lower part of the formation, consisting largely of clay, gravel, and limestone, does not extend far beyond the Arkansas-Oklahoma line. Nor does the upper part, consisting mainly of sand, extend eastward far into Arkansas; it is cut out by an unconformity at the base of the Upper Cretaceous. The Trinity in Oklahoma is thus composed largely of sand and contains little clay, limestone, and gravel which comprise so much of the formation in Arkansas. Also the formation in Oklahoma is for the most part younger than the formation in Arkansas.

The formation is thickest, about 1,000 feet, on the outcrop near the Arkansas-Oklahoma line, but thins westward to 200 feet, more or less, in Oklahoma, due partly to the overlap in the formation, and also thins out toward the east due to the unconformity at the base of the Upper Cretaceous. The formation thickens, however, toward the south away from the belt of outcrop in McCurtain County and in Arkansas, as is shown by deep wells some of which have penetrated it to a depth of 2,068 feet without reaching the base. The great thickness as revealed in deep wells, when considered in connection with the overlap here described, suggests that these deep wells may have penetrated older beds of the Trinity than are exposed on its outcrop.

The age relations and lithologic character of the Trinity formation are illustrated by the diagrammatic structure section in Figure 2.

The overlap in the formation is especially well shown by the areal distribution and stratigraphic position of some of the members of the formation that have been named and mapped by Dr. Purdue, Mr. Mesler, and the writer.

The Ultima Thule gravel lentil at its easternmost exposure in Arkansas is about 100 feet above the Pike gravel member. It thickens from a feather edge to 40 feet toward the west. As previously stated, it approaches the base of the formation toward the west and not only comes into contact with the Pike gravel near the Arkansas-Oklahoma line but perhaps completely overlaps it there.

The De Queen limestone member, which has a maximum thickness of 70 feet, is 662 feet above the base of the formation as shown by a well at Nashville, Howard County, Arkansas, but it approaches the base of the formation toward the west. At De Queen, Arkansas, it is about 150 feet above the base, and at a locality[2] $1\frac{1}{2}$ miles north of Broken Bow, McCurtain County, Oklahoma, it rests directly on the basal gravel of the formation. Honess[3] reports exposures of limestone a few feet

[1] J. A. Taff, *U. S. Geol. Survey Geol. Atlas, Tishomingo Folio*, No. 98 (1903), p. 6.

[2] *Op. cit.*, pp. 207–8. [3] *Ibid.*, pp. 207–9.

thick at points as far west as Little River beyond which the Trinity contains little or no limestone in Oklahoma except the basal chalky conglomerate mentioned on page 448. Honess, however, erroneously correlated the De Queen limestone member in Oklahoma with the Dierks limestone lentil.

The Dierks limestone lentil, which has a maximum thickness of 40 feet, is 200 feet above the base of the formation at its easternmost exposures near Murfreesboro, Arkansas, but descends lower and lower in the formation toward the west and is only about 50 feet above the base along the western part of its outcrop west of Dierks, Arkansas. This limestone occurs lower in the formation than the De Queen limestone member and occupies a part of the interval between the Pike and Ultima Thule gravels.

The De Queen and Dierks limestones contain faunas of invertebrate fossils which, according to T. W. Stanton, show a rather definite relationship to the fauna of the Glen Rose limestone of the Trinity group of Texas. Dr. Stanton's determinations of the fossils that were collected by R. D. Mesler and the writer are here given:

FOSSILS FROM THE DE QUEEN LIMESTONE MEMBER OF THE TRINITY FORMATION IN SOUTHWESTERN ARKANSAS

Serpula paluxiensis Hill
Membranipora sp.
Barbatia parva missouriensis Hill?
Avicula sp.
Ostrea franklini Coquand
Ostrea franklini var. *camelina* Cragin
Anomia texana Hill
Mytilus tenuitesta Roemer?
Cyprina? sp.
Eriphyla pikensis Hill
Astarte? sp.
Glauconia branneri (Hill)
Glauconia? sp.

FOSSILS FROM THE DIERKS LIMESTONE LENTIL OF THE TRINITY FORMATION OF SOUTHWESTERN ARKANSAS

Serpula paluxiensis Hill
Nucula sp.
Cucullaea sp.
Barbatia parva missouriensis Hill?
Ostrea franklini Coquand
Exogyra sp.
Anomia texana Hill
Modiola branneri Hill
Astarte? sp.
Eriphyla pikensis Hill
Corbicula arkansaensis Hill
Cardium? sevierense Hill
Glauconia sp.

Furthermore, the De Queen limestone contains lenses and nodules of celestite, a mineral which also occurs in the Glen Rose limestone in Texas[1] though the Glen Rose contains in addition other minerals including strontianite and the De Queen contains besides celestite some casts of salt crystals[2] and beds of gypsum 14 feet thick, which changes to anhydrite toward the south away from the outcrop.

[1] R. T. Hill, "Geography and Geology of the Black and Grand Prairies, Texas," *U. S. Geol. Survey Twenty-first Ann. Rept.*, Part 7 (1901), p. 146.

R. T. Hill and T. W. Vaughan, *U. S. Geol. Survey Geol. Atlas, Austin Folio*, No. 76 (1902), p. 3.

[2] Gilbert H. Cady has stated to the writer that he has found such casts at De Queen, Arkansas.

The limestone-bearing part of the Trinity—the part that contains a fauna similar to that of the Glen Rose limestone of Texas—is overlapped westward by the higher part of the formation which contains most of the sand of the formation (Fig. 2). That this relationship obtained and that the sand of the Trinity in Oklahoma is younger than the limestone-bearing beds were expressed opinions of R. T. Hill many years ago.[1]

The westward overlap in the Trinity in Arkansas and Oklahoma resembles a similar though northward overlap of the Paluxy sand over the Glen Rose limestone in northern Texas.[2] The Paluxy is regarded as being equivalent to at least a part of the Trinity of Oklahoma. Thus in the overlap in northern Texas beds of the same age were involved as in the Oklahoma-Arkansas area. Hence the earth movements and changes in the strand line that produced the overlap in the Oklahoma-Arkansas area were evidently coincident with the overlap in north Texas.

UNCONFORMITY AT TOP OF LOWER CRETACEOUS ROCKS

The Upper Cretaceous rocks are unconformable with the Lower Cretaceous. They rest upon older and older beds of the Lower Cretaceous toward the east, and finally come into contact with Paleozoic rocks (Figs. 1 and 2).

The Washita group, at the top of the Lower Cretaceous, consists of several formations in southeastern Oklahoma and aggregates a thickness of 350 to 460 feet in Choctaw and other counties to the west. The belt of outcrop narrows eastward in Oklahoma. This is apparently due in large measure to higher and higher southerly dips toward Arkansas, but the narrowing of the belt, especially in McCurtain County, is due to the eastward disappearance of beds at the top as a result of the unconformity separating the Washita group from the Upper Cretaceous.

On the south side of Little River at the Arkansas state line about 20 feet of the oldest formation (the Kiamichi clay)[3] of the Washita group is present. The Woodbine formation (basal Upper Cretaceous) is thus in contact with the Kiamichi there.

Neither the Washita group nor the Goodland limestone, 10 to 50 feet thick, which separates the Washita from the Trinity everywhere in Oklahoma, appears east of Little River on the west edge of Arkansas. The Woodbine formation is thus in contact with the Trinity formation east of that stream.

In Sevier, Howard, and Hempstead counties, Arkansas, the Woodbine rests upon the main bed of sand of the Trinity—the part of the formation above the

[1] R. T. Hill, "The Comanche Series of the Texas-Arkansas Region," *Bull. Geol. Soc. America*, Vol. 2 (1891), p. 511.

[2] *Ibid.*, pp. 508 and 511.

R. T. Hill, "Geography and Geology of the Black and Grand Prairies, Texas," *U. S. Geol. Survey Twenty-first Ann. Rept.*, Part 7 (1901), pp. 192–93.

W. M. Winton, "The Geology of Denton County," *Univ. of Texas Bull.*, No. 2544 (1925), p. 12.

[3] C. H. Dane, "Oil-bearing Formations of Southwestern Arkansas," *U. S. Geol. Survey Press Notice 8823*, 1926.

De Queen limestone member. But farther east in Pike County a still higher formation—the Tokio formation, of Upper Cretaceous age—cuts out by overlap and unconformity not only the Woodbine but the De Queen limestone and all the lower beds of the Trinity, including the Dierks limestone member and the Pike gravel member. The narrow outcrop of the lower beds of the Trinity ends near the eastern border of Pike County, Arkansas.

The unconformity at the base of the Upper Cretaceous is marked by a persistent bed of gravel in McCurtain County, Oklahoma, and in southwestern Arkansas. The gravel, which is thickest in Arkansas, attains a thickness of 60 feet. This, like the two beds of gravel in the Trinity formation, is composed predominantly of novaculite pebbles which had as their original source the outcrops of the Arkansas novaculite in the mountains of the north, though some of the pebbles were doubtless first laid down in the gravel beds of Trinity formation and were re-worked by streams and waves and laid down on a gravel beach in Upper Cretaceous time.

Furthermore, the earth movements that brought about the submergence of southeastern Oklahoma and southwestern Arkansas early in Upper Cretaceous time were accompanied by widespread volcanic activity. At that time the peridotite volcanoes near Murfreesboro, Arkansas, were active, as were also other volcanoes, one of which is believed to lie buried under the Woodbine formation a few miles northwest of Nashville, Arkansas, and another of which is thought to be similarly concealed about a mile south of Lockesburg, Arkansas. The quantity of material ejected, especially from the volcanoes near Nashville and Lockesburg, was enormous, and it was laid down in water in Upper Cretaceous time. The deposits of water-laid volcanic rocks were briefly described in 1925[1] and are fully described in a paper in press.[2] The intrusion of the syenites and related rocks at all the several occurrences near central Arkansas appear to have taken place at or near the same time as that of the volcanic activity near Murfreesboro, Nashville, and Lockesburg.

SUMMARY OF GEOLOGIC EVENTS

The deciphering of the events recorded in the Lower Cretaceous rocks and in the unconformities above and below them brings out several major events in the geologic history of southeastern Oklahoma and southwestern Arkansas.

1. The folded and faulted rocks of Paleozoic age and the pre-Cambrian igneous rocks were peneplaned by the beginning of Cretaceous time. The peneplain in the Ouachita Mountains is known as the Ouachita peneplain.

2. The Ouachita peneplain was tilted southward and partly submerged by the Lower Cretaceous sea in southwestern Arkansas and southeastern Oklahoma.

3. The Arkansas area was submerged first and the Oklahoma area later as

[1] H. D. Miser and C. S. Ross, "Volcanic Rocks in the Upper Cretaceous of Southwestern Arkansas and Southeastern Oklahoma," *Amer. Jour. Sci.*, 5th ser., Vol. 9 (1925), pp. 113–26.

[2] C. S. Ross, H. D. Miser, and L. W. Stephenson, "Water-laid Volcanic Rocks of Upper Cretaceous Age in Northeastern Texas, Southeastern Oklahoma, and Southwestern Arkansas," *U. S. Geol. Survey Prof. Paper* (in press).

shown by the westward overlap of the upper part of the Trinity formation (Lower Cretaceous) over the lower part.

4. The submergence of the Oklahoma area in Lower Cretaceous time was caused by a downwarping of the Texas-Oklahoma embayment that lies between the Llano and Ouachita uplifts. In consequence of this downwarping the sea extended toward the northwest and touched the Arbuckle Mountains. The downwarping is indicated by the westward overlap in the Trinity in Arkansas and Oklahoma and the northward overlap in the Trinity group of northern Texas.

5. At the end of Lower Cretaceous time there was a period of erosion. Since the greatest amount of erosion was in the Arkansas part of the Arkansas-Oklahoma area, there was then a westward tilting of the area and also a greater elevation in Arkansas than in Oklahoma.

6. The Woodbine (Upper Cretaceous) sea extended northward into southeastern Oklahoma and southwestern Arkansas.

7. After a period of erosion affecting southwest Arkansas whereby the Woodbine underwent erosion, the Tokio sea (Upper Cretaceous) spread its deposits not only on the Woodbine but across the Trinity (Lower Cretaceous) and onto Paleozoic rocks. This overlap is toward the east. The earth movements that produced the overlap were perhaps part of a regional movement that depressed the area and formed the Mississippi embayment. The first downwarping of the embayment probably began during the time that the sediments of the Woodbine formation and the largely equivalent Tuscaloosa formation of the eastern Gulf region were laid down and it continued through much of Upper Cretaceous time and into Tertiary time, though with periods of land emergence and erosion.

8. The downwarping of the Mississippi embayment in early Upper Cretaceous time was accompanied in southwestern Arkansas by volcanic eruptions near Murfreesboro and presumably at localities near Nashville and Lockesburg. It was also probably accompanied by the intrusion of nephelite syenite and related kinds of igneous rocks at Magnet Cove, Potash Sulphur Springs, Bauxite, and Little Rock, all near central Arkansas.

THE PRESENT STATUS OF THE CARBON-RATIO THEORY[1]

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ABSTRACT

The essence of the carbon-ratio theory is the assumption of a causal connection between stages of metamorphism and the occurrences of gas and oil. Many geologists are of the opinion that the observations of White, Fuller, Russell, Moulton, and other investigators constitute proof of a causal assumption in pointing out that there is a definite relationship between degrees of alteration, using the fixed carbon of coal as a pyrometer, and oil and gas occurrences. Other geologists, although not questioning the observational data indicating the relationship, are led by the serious inconsistencies in the application of the theory, in so far as its causal feature is concerned, to believe no causal connection has been proved. The chief inconsistencies are: (1) the problem of residues, (2) the occurrences of oil of lower grade in older beds below higher-grade oil in younger beds, and (3) the presence of areas producing only dry gas in quantity in the same zone of alteration with areas producing oil, and oil and gas. The writer seeks in this discussion to compare the evidence regarded as proof of the theory with these inconsistencies. The conclusion is reached that, so far as the causal part of the theory is concerned, it has the same status it had when the theory was first enunciated—an unproved assumption.

At a recent meeting of geologists engaged exclusively in oil work the carbon-ratio theory was discussed. A member-geologist had offered for consideration an idea of his own, different from that of the carbon-ratio theory, to account for the apparent relationship between the presence of gas and the quality of oil and regional alteration of the rocks. In the discussion which followed, two points of view were expressed which represented the almost unanimous opinion of those geologists present.

These points of view were: (1) the carbon-ratio theory is so well proved that geologists need not fear it will be overthrown, and (2) until a decidedly better and more logical and appealing theory is evolved geologists should be content to accept it as true. Assuming that the geologists present at this meeting constituted a fairly typical group of those to whom the carbon-ratio theory is of the greatest use, and who, accordingly, have presumably given it the most thought, these two expressions of opinion may with fairness be regarded as the prevailing attitude of most oil geologists toward the carbon-ratio theory.

Twelve years have elapsed since David White,[2] in his presidential address before the Washington Academy of Sciences, called attention to an apparent connection between certain degrees of metamorphism, as shown by the percentages of fixed carbon in coal analyses, primarily in the Appalachian and also in other oil-

[1] Manuscript received by the editor, October, 1926.

[2] David White, "Some Relations in Origin between Coal and Petroleum," *Jour. Wash.* (D.C.) *Acad. Sci.*, Vol. 5 (1915), pp. 189–212.

bearing districts, and the occurrence of gas and oils of varying gravities.[1] The theory is too well-known and understood to require repetition here. These twelve years have witnessed widespread acceptance of the truth of the relationship pointed out by White as further detailed investigations of the other great oil-producing areas of the United States have shown the observations of White to hold to a remarkable degree. These investigations, notable among which are those of Fuller[2] for Texas and Oklahoma, Russell[3] for Kentucky, and Moulton[4] for Illinois, have not only corroborated the general relationship of degrees of alteration as shown by coals with occurrences of gas and varying qualities of oil, but the numbers—the percentages—of White have been found to be the same in the other oil fields. This identity of numbers is one of the most striking features of the later work upon the carbon-ratio theory. It is fairly safe to say that the net result of all of the later checking of White's observations has shown that, regionally, the relationship stressed by the carbon-ratio theory appears to hold for the entire country.

The object of this discussion, prompted by the widely-held points of view quoted in the opening paragraphs, is (1) to inquire whether such corroboration and such identity of numbers can be called legitimate proof of the theory, and (2) to point out in the actually observed occurrences of gas and oil some of the difficulties in the way of accepting the carbon-ratio theory as true.

David White's method of treatment in the original paper was to assume that there *is* a causal connection between degrees of alteration and occurrences of gas and varying qualities of oil; then to examine coal analyses to see whether a relationship does actually exist. When a relationship was found to exist, then the causal connection was regarded as proved.

White says,[5] "At the outset it will be assumed that petroleum, as it occurs in a natural state in the oil pools in most parts of the world, is the product of the geodynamic alteration of certain types of organic detritus buried in the strata of the outer shell of the earth." He then considers the relationship between his isovols of coals and occurrences of gas and oil, and on page 210, concludes, "(1) Petroleum is a product generated in the course of the geodynamic alteration of deposits of organic débris of certain types buried in the sedimentary strata."

White accordingly believes his observations prove his primary assumption. The results of detailed work in other areas in checking White's observations would,

[1] Whenever the word "gravity" is used in the discussion of grades of oil, gravity as measured by the Baumé scale is meant.

[2] M. L. Fuller, "Relation of Oil to Carbon Ratios of Pennsylvanian Coals in North Texas," *Econ. Geol.*, Vol. 14 (1919), pp. 536-42; "Carbon-Ratios in Carboniferous Coals of Oklahoma, and Their Relation to Petroleum," *Econ. Geol.*, Vol. 15 (1920), pp. 225–35.

[3] Wm. L. Russell, "Relation Between Isocarbs and Oil and Gas Production in Kentucky," *Econ. Geol.*, Vol. 20 (1925), pp. 249–60.

[4] Gail F. Moulton, "Carbon Ratios and Petroleum in Illinois," *Illinois State Geol. Surv., Report of Investigations No. 4*, 1925.

[5] *Op. cit.*, p. 189.

therefore, be taken as further proof, so that those who regard the theory as proved would answer a question as to the legitimacy of this proof in the affirmative.

There are geologists, however, who question the scientific adequacy of a proof which simply builds up a mass of data corroborative of a given hypothesis and contents itself with no further examination. Geological laws, because of their many inexactly known factors, are incapable of the exact mathematical formulation of physical laws. No geologist expects that of any theory. But geological laws, for all of their inexactness, can legitimately claim more in the way of proof than a general assumption with multiplication of corroborative instances, coupled with a more or less general ignoring of the importance of the inconsistencies and difficulties experienced in the application of the assumption.

When the case is stated thus baldly it is probable that many geologists who regard the carbon-ratio theory as proved will be quick to think that their profound feeling of certainty in regard to the truth of the theory must rely upon something more than mere corroborative instances in the application of a plausible assumption. And yet, if they will go through all of the carbon-ratio literature of the last twelve years, absolutely the only proof of the theory they will find is the checking of White's observations by later workers in other regions and their finding his observations to be correct, as applied to large areas.

The mute but powerful reason for this acceptance of the carbon-ratio theory as proved is not hard to find. Coal, the natural hydrocarbon most nearly akin to those producing oil, almost certainly owes its different grades, from lignite to anthracite, to different degrees of metamorphism. When White and the later workers called attention to facts in the occurrences of oil and gas which seemed to imply some connection between these occurrences and stages of alteration, the critical faculties of geologists were dulled by the attractiveness and the simplicity of the notion. Their mental processes have been somewhat as follows: coal and oil are both natural hydrocarbons; the grades of the former undoubtedly are due to geophysical alteration; there seems to be some relationship between the grades of oil and the same forces; therefore the theory that the two *are* actually due to the same forces is proved.

Were the theory with its corroborative evidence, however, together with the many and extremely perplexing inconsistencies in its application, to be submitted to some group of physicists, it is safe to predict that the primary postulate of such a group would be that any theory to be proved must either be capable of demonstration experimentally or must be able to account for the inconsistencies in its application in a reasonable and convincing manner. Cumulative data on the side of corroboration must be accompanied by a corresponding decrease on the side of contradiction. When the increase of data on the affirmative side is attended by a corresponding increase of inconsistencies, the affirmative data loses its sufficiency as proof. It is the writer's belief that such a group of physicists would unite in concluding that a causal connection between metamorphism and the occurrence of gas and different grades of oil is still an assumption, not proved by the mere presence

of those corroborative instances now available. Too many difficulties have to be overlooked, difficulties which the theory is powerless to handle, for the corroborative evidence to be conclusive. We shall consider a few of the most serious of these difficulties.

It is a surprising fact that there has never been an experimental test of a causal connection between metamorphism and the occurrences of gas and oil. There have been experiments upon migration of oils, capillarity, porosity of sands, and, recently, the pressure and heat tests on kerogen, but, except for the everyday refinery processes which involve heat and some pressure—the geodynamic forces—no one has tried to prove experimentally that the natural occurrences of gas and oil can be reproduced in the laboratory as a result of heat and pressure. David White[1] makes the following comment: "In this connection it may not be out of place to note that as the conditions of nature seem more fully to be imitated in the refinery, the larger production of the lighter hydrocarbons is gained, with wider separation between them, and the residues are more fully solidified."

In considering what experimental evidence is to be had upon the carbon-ratio theory, it is of course true that the absence of corroborative experimental proof, or even a negative implication in some of the results, will not alone be sufficient evidence for discrediting the theory. The generalization that it is impossible to duplicate nature's laboratory may with fairness be applied to the experimental tests of the carbon-ratio theory. The examination, however, of the effects of the geophysical forces, heat and pressure, as shown in our closest approach to laboratory experiment, the refinery, may reasonably be considered. But it should be borne in mind constantly that experimental work that favors an idea is supporting evidence, but the mere lack of it is not alone sufficient as disproving evidence.

The writer asked the chemists of two large refineries whether by heat and pressure dry, or practically dry, natural gas could be produced from oil. Both replies were to the effect that with heat and pressure—considerably more pressure than is employed in the refining of oil—natural gas with a large gasoline content could be produced, with a residue of low-gravity hydrocarbons. If this gasoline is removed from the gas, dry natural gas is left. But in nature in the dry-gas areas of greatest alteration there is no appreciable gasoline content in the gas; nor are any heavy residues found. When these chemists were asked the direct question whether by heat and pressure alone dry gas could be formed from oils without either a gasoline content or residues the reply was that dry gas could not be so formed by any known refinery process. If this be true, then this question of gasoline content and residues, raised by the only experimental proof to which the carbon-ratio theory has ever been subjected, constitutes a very serious problem.

Particularly is the question of residues perplexing. That the formation of high-grade oils and gas from some source material by heat and pressure implies a residue of low-grade hydrocarbons—even asphalt or coke—is almost axiomatic. David

[1] David White, "Late Theories Regarding the Origin of Oil," *Bull. Geol. Soc. Amer.*, Vol. 28 (1917), p. 733.

White mentions the solidification of residues in the foregoing quotation, and felt this difficulty when he said,[1] "(2), (c), by the elimination, under certain conditions, of the heavier and more viscous hydrocarbons through filtration incident to migration."

Despite the reluctance of most geologists to admit that oil and gas have indulged in lateral migration for great distances, there can be no doubt that considerable secondary movement has taken place. If it had not, the anticlinal theory would not be true. But assuming extensive lateral migration, somewhere near the great oil and gas regions this heavy residual source material should be encountered. Actually there are no regions known which can be regarded as the areas now containing the residues left after the lighter hydrocarbons had moved off.

If migration be admitted as explaining the absence of residues and the lack of a gasoline content in dry gas, the carbon-ratio theory is then faced with the necessity of accounting for the differential migration which segregated the gas in the zones of highest metamorphism, and the oil of varying grades in zones of progressively lower alteration. There is a feature of the later discussions of the application of the theory in some areas, particularly those by Russell and Moulton, which may throw some light on this difficulty of differential migration. Both of these writers speak of the porosity of the sandstones and limestones being reduced by considerable amounts of metamorphism, which is a fact to be expected. This progressive reduction in pore space toward the zones of higher alteration might explain the presence of gas alone in the most highly altered rocks, and high-grade oil in the slightly more porous beds, and so on down. Whether rocks only slightly porous would strain the gasoline from gas in the course of the latter's migration into them is a question the writer cannot anwser. If they can dry up the gas, then the absence of a gasoline content can be explained. The fate of the enormous amounts of gasoline filtered out of the gas then becomes a problem. But with the explanation of differential migration furnished by differences in porosity—the porosity being a factor of the regional alteration of the rocks—the problem as to where the heavy residues are to be found remains unsolved.

The highly carbonized content of shales has been vaguely suggested as the residue required by the carbon-ratio theory. Aside from the obvious fact that there are many places where no highly carbonized shales are present to account for the oil, there is a large gap between the carbon content of shales and the lowest-grade hydrocarbons of the oil fields. Any process of natural distillation must be regarded as a continuous progression, rather than as a series of jumps. The question arises as to what has become of the heavy hydrocarbons lying between the lowest-grade oil and the black and blue shales of the well-cuttings. If the heat and pressure of deformation distilled the lighter hydrocarbons from a mother-source in shales, it is not very apparent why both the high-gravity and the low-gravity hydrocarbons should all be present in the sands and nothing like asphalt or even petroleum coke be found in the associated shales. If migration be invoked to explain the absence of

[1] David White, *Jour. Wash. Acad. Sci.*, Vol. 5 (1915), p. 210.

this connecting link between the lowest-grade oils and the normal marine shales of the oil fields, then somewhere in the general oil-bearing areas there should be found deposits representing this missing step; and no such deposits are known.

It is evident, therefore, that one of the most convincing methods of proof of any theory—namely, the experimental plan of trying it and seeing if it works—is lacking for the carbon-ratio theory. The only experimental evidence available embarrasses the theory more than it helps.

There are at least two other stubborn anomalies in the practical application of the theory. These are (1) the presence of oil of lower gravity in older beds underlying oil of higher gravity in younger rocks and (2) areas producing only gas in the same zone of metamorphism with areas producing oil, and oil and gas. These will be discussed in order.

Fuller[1] makes the following statement: "Any important hiatus, whether or not represented by a recognizable unconformity, is likely to be marked by a rather sudden rise of the fixed carbon in passing downward across the break." He cites examples to show this is true. It is natural to suppose that the older beds, being deeper, will have undergone greater heat and pressure than the younger strata and that, in the case of an angular unconformity, the older rocks have been subjected to at least two periods of deformation. Oil contained in these older beds should, therefore, be of a higher grade than that in the younger rocks if metamorphism is responsible for differences in gravity. As a matter of fact, the oil so found is very often of a higher gravity.

Were the oil of the deeper beds usually of distinctly lower gravity, some light might be thrown upon the problem of residues. Since there appear to be no areas horizontally which can be considered *loci* of residual deposits, it would be natural to look for them vertically, again assuming, of course, extensive migration. No relief is afforded from such a search, because, as stated previously, the deeper oils are very generally of higher gravities than the shallower oils.

Northeast of the Glenn Pool in Oklahoma, however, the oil from a 1,200–1,300-foot sand is of 37°–40° gravity, and that from the underlying 1,600-foot sand is of 33°–36° gravity. Throughout Oklahoma generally, the so-called "Bartlesville" or "Glenn" oil, of Pennsylvanian age, is of higher gravity than the underlying "Dutcher" oil, of Mississippian age. On the Sweetgrass Arch in Montana, oil of 34°–36° gravity is being produced from the Sunburst sand in the Kootenai series, while from the underlying Ellis formation of Jurassic age a low-grade oil of 29°–30° gravity is also found. A deep test recently completed on the south end of the Salt Creek structure in Wyoming had a 25-barrel showing of oil in what was probably the Morrison formation of a decidedly lower gravity than that found in tremendous quantities in the Cretaceous sands above.

The consensus of opinion among Rocky Mountain geologists, in the case of these Montana and Wyoming occurrences, is that the different grades of oil are due to original differences in material, and not to metamorphism. White[2] considers the

[1] M. L. Fuller, *Econ. Geol.*, Vol. 15 (1920), p. 227.

[2] *Op. cit.*, p. 210.

possibility of such differences when he says: "(2) The quantity and characters of the oils generated are determined by (*a*) the composition of the organic deposit at the beginning of its dynamo-chemical alteration." But if original differences in material and method of deposition—factors which White classes together as biochemical, and which he sets off in sharp contrast to the other factors of heat and pressure described as geochemical—be invoked to explain differences in quality of oils which the carbon-ratio theory cannot explain, may not these same biochemical agencies explain some of the phenomena the geochemical agencies have thus far been used to account for? In other words, may not the biochemical agencies claim a more important rôle than that of being useful merely in emergencies when the carbon-ratio theory fails?

The paper referred to in the opening paragraph which drew forth the points of view there quoted was an attempt so to use the biochemical agencies. This view, presented by Russell S. Tarr,[1] is that the major factor in different qualities of oils is due to original differences of material and to depositional agencies. He called attention to the much-overlooked fact that depositional conditions are influenced by the same broad physiographic features—geanticlines and geosynclines, positive and negative segments of the earth's crust—which later influence deformation and, accordingly, metamorphism. He asks the very pertinent question whether, in the light of these facts, the apparent relationship between stages of metamorphism, as shown by coal analyses and occurrences of gas and oil, may not be a mere coincidence. If this is so, then the degree of metamorphism and the occurrences of gas and oil are both to be considered as secondary effects of a common cause, rather than as the two results being causally related.

In this connection the writer would record having found an extremely high-grade hydrocarbon, closely akin to kerosene, in seepages in swamps south of Augusta, Georgia. Using the utmost diligence to guard against "salting" of any kind, he concluded that the many spots from which this colorless, high-grade hydrocarbon was obtained could only indicate it was actually being deposited along with the muds of the swamps. This observation has been checked by a later worker in a different area who had this colorless material analyzed at a refinery, and it proved actually to be very closely allied to kerosene. But the general notion has always been that the mother-source for oils was of a relatively low gravity before the geodynamic forces began work upon it.

If Tarr's idea of attributing the primary differences in oils and the formation of gas to depositional factors be correct, there is no problem of residues. Similarly, dry gas is originally different from that associated with oil. (He regards dry gas as a result of continental or semi-continental deposition. A great deal of gas was obtained in the same Georgia swamps mentioned previously, associated with the high-grade hydrocarbon.) Being formed under different conditions, this gas never had a gasoline content. This idea, or theory, immediately avoids the most serious diffi-

[1] Russell S. Tarr, "Oil May Exist in Southeast Oklahoma," quoted by C. D. Lockwood, *Oil and Gas Journal*, Vol. 24, No. 30 (December 17, 1925), p. 51.

culties of the carbon-ratio theory, while proposing an adequate and logical explanation of the apparent relationship between degrees of alteration and oil and gas fields.

The existence of areas producing only gas, surrounded by areas producing oil, and oil and gas, as previously mentioned, is a further difficulty with which the carbon-ratio theory has to deal. In southeastern Kansas certain structures, locally referred to as "Mississippi lime highs," produce nothing but practically dry gas, and produce it in quantity, while the surrounding areas produce oil, and oil and gas. All of these structures lie in the same general region of alteration. It is obvious that some factors other than regional heat and pressure will have to be invoked to account for this relationship. Original differences in material may again help out, but the carbon-ratio theory is powerless.

The great gas area of the Texas Panhandle is another curious anomaly. Here, for many square miles, on the top of the great arch present in the older rocks, gas only is found. At certain definite levels, however, on the sides of this structure, oil is found, but the oil is not of the highest gravity. There is no distinct zone of intense metamorphism characterized by parallel folds of less intensity, with the oil found in the latter and the gas in the former. The medium-grade oil is found on the sides of the great arch which produces gas from its top, and at this writing there has been found no zone of high-grade oil lying as a transition belt between the lower-grade oil and the gas.

Some oil fields, moreover, produce as great a quantity of gas as has ever been found in the dry-gas areas of the country, although in the case of the former there is usually an appreciable gasoline content. The Cushing and the Cromwell oil fields in Oklahoma produced gas wells practically as large as any ever drilled in the world. In both of these fields gas wells with a capacity of one hundred million cubic feet a day, or even more, were not at all rare. Yet the gravity of the oil in these pools, 34°–38°, is not the highest-grade oil in the state. The Tonkawa and Garber fields produced a considerably higher-grade oil, with notably smaller quantities of gas.

If progressively greater degrees of alteration are accompanied by progressive distillation of the hydrocarbons, with gas as the limit, then in those areas containing the largest percentages of gas the highest-grade oils would logically be expected. As already shown, this is not a fact. Here, once more, the aid of original differences of material and method of deposition will offer a thinkable way out of the difficulty.

From this brief review it is hoped a few of the most obvious difficulties experienced in the application of the carbon-ratio theory may be sufficiently clear to raise a doubt concerning the adequacy of the so-called "proof" of the theory. The endeavor has been made to bring out the fact that a causal connection between stages of alteration and occurrences of oil and gas is still an assumption. No causal connection has been adequately shown in an experimental way. The corroborative instances are found to lose a great deal of their persuasiveness when the difficulties in the detailed application of the theory are reviewed. These difficulties the theory

is powerless to handle. A way out can only be had by invoking the very agencies which the theory is generally understood to make subordinate. Geologists should cease to speak of the carbon-ratio theory as proved.

CONCLUSIONS

A causal connection between degrees of alteration and occurrences of gas and oil of different grades has never been proved. It is still purely and simply an assumption. Tarr has briefly outlined an extremely important suggestion, namely, that stages of alteration and occurrences of gas and oil may be the results of a common cause; and when this common cause is overlooked, there appears to exist a causal connection between the results. Of the difficulties with which the carbon-ratio theory is powerless to cope, there are three which are most obvious: (1) the problem of residues, the most serious of all the difficulties; (2) the presence of oil of heavy gravity beneath oil of lighter gravity; and (3) the occurrence of dry-gas areas surrounded by oil-bearing areas, and of structures yielding a medium grade of oil along with tremendous quantities of gas. Original differences in material, or original differences in place or method of deposition, will explain away all of these difficulties.

To oil operators the relationship pointed out by White, concerning the existence of which there can be little doubt, will continue to have the same value it always has had in pointing out unpromising areas for oil prospecting. The commercial value of the carbon-ratio theory lies in the empirical fact of the relationship itself, not in its causes. The question of causes is strictly a geological problem, subject to the rigorous exactions of scientific methods for its proof. These methods, in so far as they have been applied to the carbon-ratio theory, have not been productive of an adequate proof. The status of the theory today, therefore, appears to be that of an unproved, though dangerously pleasing, assumption.

DISCUSSION

RUSSELL S. TARR: Dr. Dorsey's paper has been read with a great deal of pleasure, and the opportunity to discuss it is welcomed. The writer hopes it will reopen discussion of a theory that he feels is not acceptable in its economic application. Further discussion and study of the subject may open new territory for oil and gas prospecting.

In a talk given before the Tulsa Geological Society in the early fall of 1925 and in an article in the *Oil and Gas Journal* of December 17, 1925, the writer outlined his views on this subject. Comment was limited, and, while not wholly unfavorable, it did not cause the discussion desired. It is hoped that this article, supplementing the preceding one, will revive interest.

Dr. Dorsey has admirably presented the carbon-ratio theory and its main points, as well as the many objections. Both he and the writer believe that the carbon-ratio contours for any given region are essentially correct. The writer has, however, attempted to prove that their relation to oil and gas production is a coincidence due to a combination of circumstances rather than a causal relationship. In order to understand this coincidence, it is necessary to review the depositional and tectonic history of Oklahoma. (This state is

chosen because of the writer's familiarity with it, but the Pennsylvania and West Virginia fields have a distinctly similar history.)

Throughout Mississippian times, a sea occupied a large part of Oklahoma, depositing marine sediments; while from a land mass at the south or southeast was derived a large amount of detrital material. This condition naturally caused the deposition of less lime and more mud and sand in the southeastern counties, grading into continental beds along an unknown line, or series of lines, depending upon the stability of the shore line. Farther north we find the well-known "Mississippi lime" as the equivalent of the thicker Mississippian section at the south. A characteristic of this series of beds is its black color, due, of course, to a large percentage of carbonaceous material.

Following the Mississippian-Pennsylvanian unconformity we find a similar relationship, differing only in one essential—that the boundary line between marine and continental deposition has moved farther north and west and continues to do so during most of the lower Pennsylvanian deposition. Of course, this gradual northward encroachment of the continental fans is not steady, and there are marine invasions of already conquered territory. The northward advance is probably due to the large amount of material previously deposited, and perhaps to some extent to the beginning of Ouachita-Arbuckle folding.

The important fact to be noticed is that the percentage of dominantly continental beds is greater in the southeastern regions and the percentage of dominantly marine beds is greater in the northern regions. It should also be noticed that the oil fields occur in a region where the beds are mostly marine.

As we progress southward from Okmulgee, let us say, we find a very abrupt zone of gradation, south of which there is little or no oil found, only gas. Northward, northeastward, and westward lie many oil fields. If the carbon-ratio theory is to hold true, it seems strange that there is such an abrupt line of change. With the slow variation in degree of metamorphism as expressed by the carbon-ratio contours, it would seem as if there should be an equally slow variation in oil and gas percentage. Furthermore, as Dr. Dorsey has pointed out, one would also expect a certain amount of residue to be found in the gas sands. Neither of these conditions exists; in fact, the direct opposite is true.

While on the subject of the separate occurrences of oil and gas, it is worth while to mention a few peculiarities of the Lyons, or Papoose, sand production. The Lyons pool in eastern T. 11 N., R. 11 E. is a prolific producer of oil with little gas from the Lyons sand (probably a sandy phase of the Pitkin lime). This same sand in western T. 11 N., R. 11 E. and in the Okemah pool of southeastern T. 11 N., R. 9 E. is a prolific producer of gas with little oil. The same relationship holds true in Sec. 15, T. 11 N., R. 9 E. (gas) and the Papoose pool of northern T. 9 N., R. 9 E. and southern T. 10 N., R. 9 E. (oil), as well as in many other pools and other sands. As the degree of folding does not seem to explain it satisfactorily, this relationship must be attributed to some other cause. It appears probable to the writer that this cause must be something associated with the deposition of the producing sand, the oil source, or both. Is it not possible that the study of marine or continental deposition with the associated study of the complexities of deposition, will solve this problem? Is it not possible that the abrupt line of separation between the oil and gas-producing areas of Oklahoma is due to conditions surrounding deposition and not to metamorphism?

It may be pointed out that the carbon-ratio contours follow this line of separation rather well. If we review a few well-known facts, however, this coincidence may be explained in another way.

Major geosynclines and geanticlines have tended to preserve their axes throughout geologic time. In every period of movement they moved in much the same way as in the preceding one, differing only in intensity. The overloaded Ouachita-Arbuckle geosyncline was folded into mountains of the same name and had an axis parallel to that of the land mass from which its sediments were derived. Consequently, throughout its entire history, this region had a series of roughly parallel shore lines, because the structural axes remained the same. Since the shore lines were parallel, the zones of deposition were roughly parallel. If we follow this idea still further, we will find that the later Pennsylvanian folding took place along structural axes parallel to the axes of the previous land mass, the old geosyncline, and the zones of deposition of the earlier sediments. Metamorphism has taken place in decreasing intensity as we proceed away from the center of the mountain mass. Consequently we find that the carbon-ratio contours are roughly parallel to the axes of folding and therefore to the zones of deposition and the old shore lines. Thus there exists a condition, unexpected, perhaps, through which the parallelism of carbon-ratio contours to the dividing line of oil and gas areas can be explained very well by the "depositional theory" instead of the carbon-ratio theory.

In its economic application, the carbon-ratio theory has discarded all possibilities of oil being found in the folded regions of southeastern Oklahoma. As a matter of fact, oil has actually been found in several places well within the discarded area. On some of the big anticlines of Pittsburg and Coal counties, the Wapanucka limestone and the Caney shales are within drilling depth. Since these beds have been deposited under marine conditions, it is thought that there is a distinctly good possibility of obtaining oil in them. The writer believes that such anticlines deserve a thorough test and understands that a test-well will be drilled soon, due to the interest and belief of Mr. J. R. Riggs of the Indian Territory Illuminating Oil Company. This well will be watched closely, and should it result in oil production, will do much toward clearing up some doubtful points.

WESTBROOK FIELD, MITCHELL COUNTY, TEXAS[1]

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ABSTRACT

The Westbrook oil field is doubly worthy of description because it is the discovery field of western Texas and because oil was found in Permian strata, previously not seriously considered as oil-producing beds. Since the first producer in 1920, a 10-barrel well at 2,498 feet, 77 wells have been drilled, averaging 40 barrels each. Early in 1926, 8 were producing. The Triassic extends from the surface to 500 feet in depth; the remainder of the section is Permian. Several key beds in the Permian are used to map the subsurface structure which is that of a northeast-southwest anticline. The 2,400-foot pay and the 3,000-foot "Morrison sand" are themselves good markers, occurring along porous zones within definite vertical limits. The productive reservoir is dolomitic limestone. The oil has a gravity of 25.8 degrees Baumé. and contains 4 per cent sulphur, and 32 per cent gasoline. Its source is probably the Permian limestones and shales. Two kinds of gas occur in the field: (1) non-inflammable gas at depths between 1,000 and 1,300 feet, and (2) wet petroleum gas in both oil zones.

INTRODUCTION

The Westbrook field in Mitchell County, Texas, is worthy of special reference since it was the first commercial pool to be discovered in west Texas. In addition to being the discovery pool, it has remained of interest because of the fact that the oil encountered was obtained from Permian strata, previously thought to be of little consequence as an oil producer.

LOCATION AND EXTENT

The Westbrook field is located about two miles northwest of the town of Westbrook, Mitchell County, Texas (Fig. 1).

In its present development, it is about 6½ miles long and 1½ miles wide, and has a general northeast-southwest alignment.

HISTORY OF THE FIELD

The first well to be drilled in the Westbrook field was the Texas and Pacific-Abrams No. 1. This well is located in the extreme northwest corner of Sec. 33, Block 28, T. 1 N. It is stated that this was not the original location selected for the well, but it was made here due to the fact that the wagon hauling the boiler to the location bogged down at this point. As the boiler had to be taken off, it was decided to change the location and drill the well at its present site. The Underwriters Producing Company drilled the Abrams No. 1 well. It was spudded in,

[1] Presented before the Association at the Dallas meeting, March, 1926. Manuscript received by the editor, February 3, 1927.

February 8, 1920, and completed March 5, 1921, as a 10-barrel pumper, with a total depth of 2,498 feet. The production came from a brown dolomitic limestone

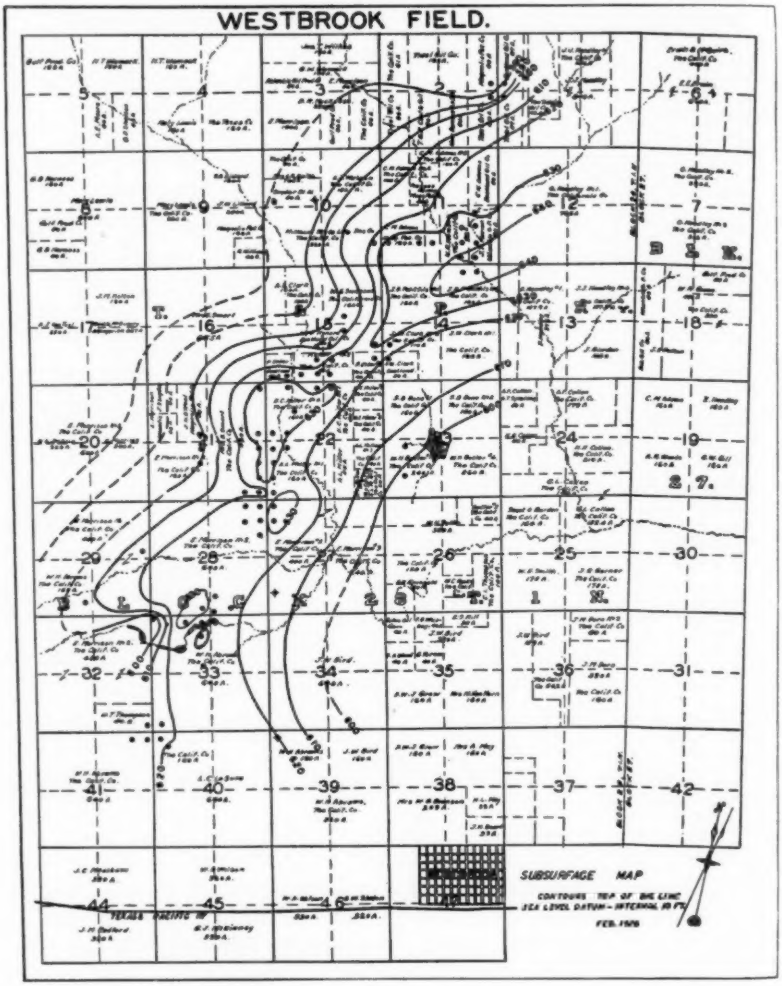

FIG. 1

from 2,348 to 2,498 feet. This well was later deepened to about 3,000 feet by The California Company and is now producing from the lower pay horizon.

The second well to be drilled was the Morrison No. 1. This well is located in

the northeast corner of Sec. 32, Block 28, T. 1 N. It was spudded in, May 28, 1920, but was only drilled to 440 feet to test a shallow showing which had been encountered in drilling the Texas Pacific–Abrams No. 1 well. It was abandoned at that depth and later used as a water well.

The Morrison No. 2 was the next well to be drilled. It is located in the southwest corner of the SE. $\frac{1}{4}$ of Sec. 28, Block 28, T. 1 N. This well was spudded in, October 25, 1920, and completed to a depth of 2,425 feet, January 9, 1921. It was drilled by the Underwriters Producing Company. The initial production was 15 barrels, but the well soon settled to a 3-barrel pumper. It was later deepened and a lower pay horizon of brown dolomitic limestone encountered from 2,916 to 2,952 feet. This pay horizon was called the "Morrison sand" from the fact that it was first encountered in the Morrison well. The Morrison No. 2 was drilled to a total depth of 2,972 feet and completed April 1, 1921. The well flowed by heads at the rate of about 50 barrels a day, but after some water trouble was overcome and the well put on the pump, it had an initial production of 200 barrels of oil a day. This well has been one of the best wells in the field and has produced about 120,000 barrels of oil to date. It is still producing 40 barrels a day.

The next well to be drilled was the Le Sure No. 1, located in the northwest corner of the NE. $\frac{1}{4}$ of Sec. 40, Block 28, T. 1 N., which spudded in April 15, 1922. Its total depth was 3,070 feet and its initial production, 50 barrels. This well extended the field about one mile southwest.

The Texas and Pacific–Abrams No. 2, located in the northwest corner of the NE. $\frac{1}{4}$ of Sec. 33, Block 28, T. 1 N., offsetting the Morrison No. 2, spudded April 22, 1922. It was completed November 4, 1922, as a 15-barrel pumper at a total depth of 3,174 feet. This production was later increased to about 30 barrels and still later to 60 barrels, when the well was reconditioned by The California Company.

The Smart No. 1 well, drilled by Sam Sloan *et al.*, located in the southeast corner of the SE. $\frac{1}{4}$ of Sec. 21, Block 28, T. 1 N., was spudded December 2, 1922, and completed April 13, 1923, at a total depth of 2,980 feet. This well's initial production was 150 barrels. The well was later deepened to 3,030 feet after the production had declined considerably and was reconditioned September 2, 1923, as a 150-barrel pumper. This well extended the field one mile northeast from the discovery well.

The C. F. Kelsey *et al.*–Badgett No. 1 well located in the northeast corner of the SE. $\frac{1}{4}$ of Sec. 2, Block 28, T. 1 N., was spudded November 11, 1922. The well was completed January 2, 1924, as a 50-barrel pumper at a total depth of 3,064 feet. This well extended the field 5 miles northeast from the old Morrison No. 2 well.

In December, 1922, the holdings of the Underwriters Producing Company were taken over by The California Company and since that time several wells have been drilled, most of which have been along the northeast extension from the Morrison No. 2 well.

There are now 77 producing wells in the Westbrook field with a total daily production of about 3,400 barrels, making an average daily production of about 45 barrels a well. At present, March 26, 1926, there are 8 wells drilling.

TOPOGRAPHY

The field lies on a nearly flat plain with here and there small hills of Triassic sandstone and conglomerate, rising 20 to 30 feet above the general level. Small intermittent creeks drain eastward into Colorado River.

GEOLOGY

Areal geology.—The formations exposed in the vicinity of the Westbrook field, and in fact over the greater part of Mitchell County, consist of red and gray sandstones and red shales of Triassic age, covered in part by more recent deposits.

The Triassic formations as shown by the well cuttings have a total thickness ranging from 400 to 500 feet.

The lithology of the Triassic is that of reddish to gray micaceous sandstone, sometimes conglomerate with blue and red shale breaks 10 to 20 feet thick. The base of the Triassic is marked by a water horizon.

Subsurface geology.—Underlying the Triassic is the Permian series. Extending from 500 feet below the surface to 1,500 feet, the Permian consists of red sand and shale, salt, gypsum, and anhydrite. Below 1,500 feet the Permian series consists almost entirely of dolomitic limestone. From our present correlation, the Permian formation from the base of the Triassic to 2,200 or 2,300 feet is placed in the Double Mountain epoch. From 2,200 or 2,300 feet to about 3,200 feet, it is believed to be Clear Fork; from 3,200 feet to about 4,200 feet, Wichita. Below this is Cisco, of Pennsylvanian age (Fig. 2).

The 2,400-foot pay discovered in the Texas and Pacific–Abrams No. 1 well probably occurs near the Double Mountain–Clear Fork contact.

If this correlation is correct, the "Morrison sand" or main pay horizon occurs near the base of the Clear Fork.

Although the Morrison 3–No. 1A well, located in the southwest corner of Sec. 27, Block 28, T. 1 N., T. & P. Survey, was drilled to a depth of 5,305 feet, no further pay horizon was encountered below the "Morrison sand."

Surface structure.—In the immediate vicinity of the Westbrook field no surface structure has been worked out. The Triassic beds have only a regional dip to the northwest. Surface structures have been mapped in the Triassic formation at several places in Mitchell and Scurry counties, but from subsequent developments, these have all been proved not to be reflections of the subsurface structures influencing the accumulation of the oil.

Subsurface structure.—The subsurface structure of the field, based on a key horizon in the Permian, as can be seen from the accompanying structural map, is a long, very irregular anticline with a northeast-southwest trend in the form of a bow.

The east side of the field shows a definite reversal of at least 30 feet. It is believed that the reversal in the Permian on the east side of the field is not very great because of the regional relationship to wells which have been drilled beyond the limits of the map presented. In addition to the slight reversal which occurs

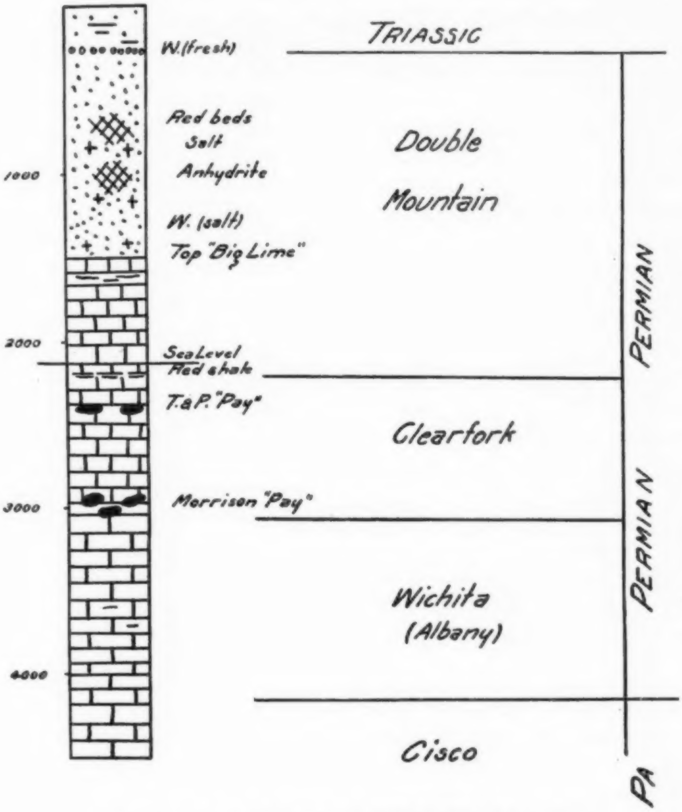

FIG. 2.—Type log for Westbrook field, Mitchell Co., Texas

on the east side of the field it is evident from the behavior of the wells along this side of the field that the pay horizon does not have the same porosity as that found by the wells on the west. These two factors determine the limit of production along the east side.

Neither the northeast nor the southwest end of the field can be defined to date because no wells have been drilled close enough to show the limits of the field in these directions. The south end of the field is a few feet lower structurally than

the north end, and it is believed quite possible that the anticline plunges slowly and irregularly in that direction. The next control in a northeast direction from the producing field is the Fensland-Badgett No. 1 well located in Sec. 62, which is a dry hole. This latter well is 140 feet higher structurally than the most northern wells in the field. The steep rise in structure from the Ricker and Womack wells in the north end of the field to the Fensland-Badgett well is far in excess of the rate of rise in the remainder of the field. Two explanations may be given as to what may have happened northeast of the present pool. It is thought that either a fault occurs between the Fensland-Badgett No. 1 and the Womack and Ricker wells, or that the porosity decreases northeast of the field. Under the first hypothesis the field would be located on the down-drop side of the fault and the oil sealed off from further migration by this fault. If this is found to be true, future wells may prove to be consistently better toward the northeast up to the fault line. If, however, the limit of production in the northeast direction is due to the decrease in porosity in the pay horizon, the wells will then be poorer in that direction. Future drilling is the only method of determining which hypothesis is correct and where the northeast limit of the field may be.

There are four horizons in the Westbrook field which may be used as markers for drawing subsurface maps of the field. At a depth of 1,250 feet, more or less, a water sand occurs in the red beds, which is persistent throughout the area. This horizon may be used to contour the field. It occurs about 250 feet stratigraphically above the top of the "Big lime" which is the second best marker on which to contour. The 2,400-foot Texas and Pacific pay makes the third marker and the main 3,000-foot pay, or "Morrison sand," the fourth. The latter two, however, are not very good for depicting the structure of the field, because they do not represent one particular horizon, but occur along porous zones within certain vertical limits. The structure of the Westbrook field as represented on the map accompanying this report has been prepared using the top of the "Big lime" as the key horizon.

OIL

Occurrence.—The reservoir of the Westbrook field consists of two zones in dolomitic limestone containing two or more porous streaks ranging from 10 to 40 feet thick. These zones contain very little sand, 5 per cent at the most. A microscopic examination of the cuttings shows the presence of minute euhedral crystals of quartz such as one finds developed in cavities or vugs. Samples blown from the wells when they are shot show the rock to be a dense, massive, brownish-gray dolomite with small almost microscopic cavities and pore spaces. The rock has a mottled appearance because of the presence of many small oval calcite fillings. It is not oölitic, like the Santa Rita pay of the Big Lake field in Reagan County.

The origin of the porosity in the productive horizons is an interesting subject for investigation. Three suggestions may be offered. First, the porosity may have developed during the process of dolomitization with its attending shrinkage in volume of the rock. If the dolomite was laid down as a primary deposit, however,

or if the dolomitization process was contemporaneous with the deposition of the lime, the porosity of the pay horizon could not be explained in this way. A second and more reasonable explanation of the origin of the porosity would seem to be the circulation of underground waters. With the dolomite occurs anhydrite in small amounts in lenses and laminae and intimately intermixed with the dolomite. Underground circulating waters carry away part of the anhydrite through differential solution, leaving the pay zones porous. Some of the porosity of the pay zones is due to incipient fractures in the rock. Samples ejected from the wells when they are shot demonstrate this.

While we may conjecture as to the cause of the porosity of the reservoirs, the known facts about the pay horizons are that they are neither sands nor definite beds, but that they occur as zones within well-defined vertical limits.

The behavior of the wells shows that porosity is not the same in all directions. Offsets drilled near a group of wells will affect some of these producing wells more than others. Frequently there is a very marked falling off in the production of the older wells when new ones are drilled in. The degree of porosity is very irregular over the field and to date it has been impossible to define areas where it could be predicted.

Source.—The source of the oil is probably in the marine Permian limestones and shales. This opinion is based not on observations from the local Westbrook field alone, but from a study of the lithology and character of the Permian sediments in most of west Texas. In speaking of the marine Permian limestone and shales as sources for the oil, we refer specifically to the Wichita-Albany and Clear Fork series, which in many places contain considerable organic content.

Analysis.—The oil is dark brown in color and is of a mixed paraffin and asphalt base. Analysis shows the following:

Gravity	25.8 degrees A.P.I. Baumé
Sulphur	$3\frac{1}{2}$–4 per cent
Gasoline	31.98 per cent

Production.—At the present time there are 77 producing wells in the Westbrook field, with a total production of about 3,400 barrels daily, which makes an average of nearly 45 barrels per well per day.

The wells drilled have had an average initial production of 75 barrels per day. This figure represents the average daily production for the first month of settled production.

The decline of the wells can be ascertained from the accompanying family curve (Fig. 3). This family curve was constructed from the wells of the Kynerd lease. This particular lease was used because it is located in the central part of the field, and represents a fair average of the rate of decline for all of the wells of the field.

It is the practice to shoot all the pay horizons in the field from which production is obtained. This is done because it increases the production greatly, especially

where the pay horizon is non-porous and hard. The oil string is landed 150 to 200 feet above the producing horizon. This is found to be far enough up the hole for the casing to be undisturbed by the shot.

GAS

There are two distinct kinds of gas encountered in the drilling of wells in the Westbrook field: (1) a non-inflammable gas encountered in the Permian Red Bed series at depths between 1,000 and 1,300 feet; (2) a wet petroleum gas occurring with the oil at the two pays, namely, the 2,400-foot zone, and the 2,925–3,000-foot zone.

Non-inflammable gas.—One of the interesting developments of the field was the non-inflammable gas. The gas was first encountered at 1,035 feet in drilling the Badgett No. 1 well, located in Sec. 62, Block 97, Mitchell County, during the latter part of September, 1922. It was estimated that the flow of gas at this time was about 20,000,000 cubic feet. On deepening the well about 30 feet, another gas horizon was encountered and the flow of gas increased to about 50,000,000 cubic feet. At this time, or shortly thereafter, water was encountered, and the well flowed about 10,000 barrels of salt water per day, in addition to the gas. The well flowed salt water and gas about five months, then only gas about two months before it exhausted itself or sealed itself off.

The interesting data relative to this gas are here set down:

1. The composition of the gas can be determined from the following analyses:

	Analysis Made for the California Company		Analysis Made for The Oil Weekly
	Sample No. 1 Per Cent	Sample No. 2 Per Cent	Sample No. 1 Per Cent
Carbon dioxide	0.2	None	0.1
Oxygen	0.7	1.2	Not given
Methane	14.2	3.2	5.6
Ethane	0.8	None	1.1
Nitrogen	84.1	95.6	93.2
Helium	....	0.014	....

In all of these analyses the nitrogen content is very high, the ethane low, and the methane relatively high.

It would be difficult to attempt to explain the origin of this gas. From its high nitrogen content, its relatively high methane content, and its low oxygen and low carbon dioxide content, the gas may be either of organic origin or trapped air which has undergone some change, or a combination of the two.

2. This gas has been encountered in varying amounts in several of the wells drilled in the Westbrook field and in southern Scurry County. In three of these wells, namely, Badgett No. 1, Sec. 62, Block 97, Mitchell County, Moore No. 1, Sec. 16, Block 97, Scurry County, and Welborn No. 1, Sec. 103, Block 97, Scurry County, the non-inflammable gas was found in sufficiently large quantities to be

used in a regular drilling engine for power purposes. The two last-mentioned wells were drilled in this way, and later pumped by the use of this gas. In some of the wells of the Westbrook field the quantity of gas was large enough to have been of value for power purposes, but was in such close contact with a water-bearing stratum just below it, that it had to be mudded and cased off. In the Scurry County wells this objectionable water stratum seems to be absent, and the gas is easily bradenheaded off and used for power. In using the gas for power it is run into a regulation steam boiler, the safety valve set at the pressure desired and used in the same manner as compressed air. A regular drilling engine was used in

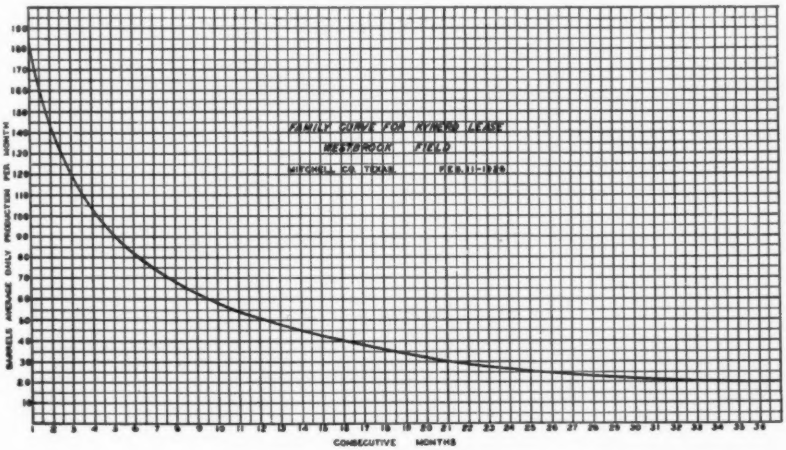

FIG. 3

all cases, the only changes necessary being the enlarging of the exhaust pipe and the use of low temperature oil for lubrication.

3. The gas sand evidently extends over a large area, but at the present time it is impossible to say whether it will be continuous over this entire area or not. Probably its extent will be very irregular.

4. The gas is colorless, odorless, and non-inflammable. Attempts were made to burn this gas at all of the drilling wells where it was encountered, but it was found to be non-inflammable. In the old Badgett No. 1 well, however, it was set on fire on two different occasions and burned several days each time, with a colorless flame. The gas did not burn directly over the hole, but burned on one side of it where it was passing up through a large mass of salt that had been deposited by evaporation from the supersaturated salt water which had been ejected from the well along with the gas. Since the amounts of oxygen, methane, and ethane present in the gas vary considerably, as can be seen from the analyses, it is not known

whether the combustion of the gas in this case was due to a change in composition, or the gas coming out of the salt was more free from moisture, or whether the salt had some sort of catalytic action on the gas.

Petroleum gas.—This gas, as previously stated, occurs with the oil. The upper pay horizon carried very little gas, the greatest amount being found with the main "Morrison sand." The gas is very wet and has from 4.25 to 4.75 gallons of gasoline per thousand feet. It has a specific gravity of 0.87 to 0.97.

The amount of gas is variable in the different wells, ranging from an amount so small as to be practically impossible to measure, to 40,000 cubic feet per well per day. The amount of gas is also somewhat irregular from day to day in the same well.

THE RELATION OF STRUCTURE TO PRODUCTION IN FIVE OIL AND GAS FIELDS OF THE KENTUCKY EASTERN COAL FIELD[1]

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ABSTRACT

The structure and related production are described in five oil and gas fields of the eastern coal field of Kentucky, namely (1) the Lee-Estill-Powell oil field, (2) the Campton oil field, (3) the Owsley County gas field, (4) the Clay County gas field, and (5) the Elliott County oil field. The producing beds are Pennsylvanian, Mississippian, Devonian, and Silurian in age, the next important being the Corniferous limestone of the Devonian. The major structural features of the general area are the Cincinnati Arch and Paint Creek uplift, whose axes extend north and south, and the Pine Mountain and the Irvine-Paint Creek faults and uplifts, whose axes extend east and west. These two systems of folding are dominant features in eastern Kentucky. The Cincinnati Arch has had a marked effect on both structure and stratigraphy. It was probably a positive element throughout the time of deposition of the formations in these fields. Formations increase in thickness with distance from the arch, and minor folds parallel the arch. Subsequent folding and faulting with east and west axes were the result of pressure from the south. Production is related to structure only in a general way; the porosity of the sands and limestones seems to be the controlling factor for oil and gas accumulation. Several wells have been drilled in the Elliott County oil field proving the crest of the main fold to be dry, probably because of unfavorable sand conditions. An interesting feature of the map of the eastern coal field is the relation of the oil and gas production and the isocarbs to the major uplifts and faults. The Irvine sand pools, which produce 60 per cent of the oil in the state, lie along the flank of the Irvine-Paint Creek uplift, paralleling the Irvine-Paint Creek fault. The Wier pools, which produce 30 per cent of the state's oil, lie along the axis of the Paint Creek uplift. This close relation of production to uplift bears out the theory that oil was formed during, and as a result of, folding, rather than having been formed prior to the fold and having subsequently migrated into it. Folding seems essential to oil accumulation in eastern Kentucky, but the degree of folding must not pass beyond a certain point or the hydrocarbons will be changed to gas. The most favorable formations for producing oil are stratigraphically high, geologically young, and moderately folded. The probability of finding many new oil fields of importance is not large.

INTRODUCTION

The author attempts to show in this paper the relation of oil and gas production to folding in five oil fields of the eastern coal field of Kentucky, the Lee-Estill-Powell oil field, the Campton oil field, the Owsley County gas field, the Clay County gas field, and the Elliott County oil field.

The location of the eastern Kentucky coal field is shown in Figure 1, and the locations of the oil and gas fields are shown in Figure 2.

The field work on which the structure maps in this report are based was done during the years 1921 and 1922 by the members of the geological department of Petroleum Exploration, Inc., Lexington, Kentucky.

Correlation of beds is largely from the publications of the Kentucky Geological Survey.

[1] Paper presented before the Association at the Tulsa meeting, March, 1927.

[2] Wiser Oil Company, Bartlesville, Oklahoma. Introduced by Frank R. Clark.

STRATIGRAPHY

The succession of beds encountered in eastern Kentucky is shown graphically in the cross-section, Figure 3. All of these beds outcrop between the axis of the Cincinnati Arch and the Virginia state line. In descending order, they are the upper Pottsville coals, shales, and sandstones, and the lower Pottsville sandstone-conglomerate and coals, of Pennsylvanian age; the Mauch Chunk shales, sands, and limestones, the St. Louis limestone, and the Waverly shales and sandstones, of the Mississippian; the Chattanooga black shale and Corniferous limestone of the Devonian; the Niagara shales and limestone of the Silurian; and the Richmond

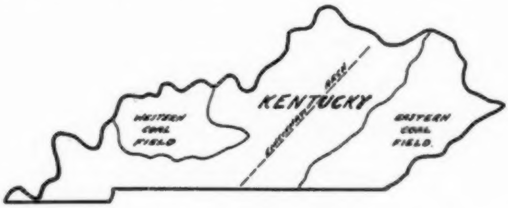

FIG. 1.—Outline map of Kentucky, showing location of eastern coal field

shales and Lexington limestone of the Ordovician. In this columnar section the beds producing oil or gas in the eastern coal field are shown in Table I.

TABLE I

BEDS PRODUCING OIL OR GAS IN THE EASTERN COAL FIELD

Age	Formation	Bed
Pennsylvanian	Pottsville conglomerate	Salt sands
Mississippian	Mauch Chunk	Maxon sand
Mississippian	Waverly	Wier and Berea sands
Devonian	Corniferous	Corniferous limestone
Silurian	Niagara	Clinton sand

In addition, some gas is encountered in the St. Louis limestone and the Big Injun sand at its base, of Mississippian age.

STRUCTURE

The major folds and faults of the eastern coal field are shown in Figures 1 and 2, namely, the Cincinnati Arch, the Pine Mountain fault and uplift, the Irvine-Paint Creek fault and uplift, and the Paint Creek uplift. It should be noticed that the axes of the Cincinnati Arch and the Paint Creek uplift extend approximately north and south and the Pine Mountain and Irvine-Paint Creek faults and uplifts trend approximately east and west. These two systems of folding are apparent in all the structural folds of eastern Kentucky. Each fold has a minor axis at right angles to the major axis.

The Cincinnati Arch has had a marked effect not only on the structure of the

eastern coal field but on the stratigraphy as well. This arch seems to have been a positive element during all the times here under discussion, as shown by the thickening of beds away from the arch (see Fig. 3). The history of this arch as interpreted from these beds is interesting.

ORDOVICIAN, SILURIAN, AND DEVONIAN TIMES

There is evidence that the arch existed soon after the close of Ordovician times, as the Silurian beds show a rapid thickening away from the axis of the arch, and

FIG. 2

also a change from shale and sand, shallow-water deposits, to limestone, a deep-water deposit. The Corniferous limestone shows the same thickening, but to a lesser degree, showing that the rise during this period was small. The Devonian black shale, however, shows a change from 100 feet of thickness in Powell County to 700 feet in Knott County, indicating a considerable rise either just prior to, or during, the deposition of the black shale in the shallow waters of the Devonian seas. It is also possible that the uplift occurred after the deposition of the shale and that erosion removed the greater part from the crest. The general history, however, indicates a slow continuous rise of the arch.

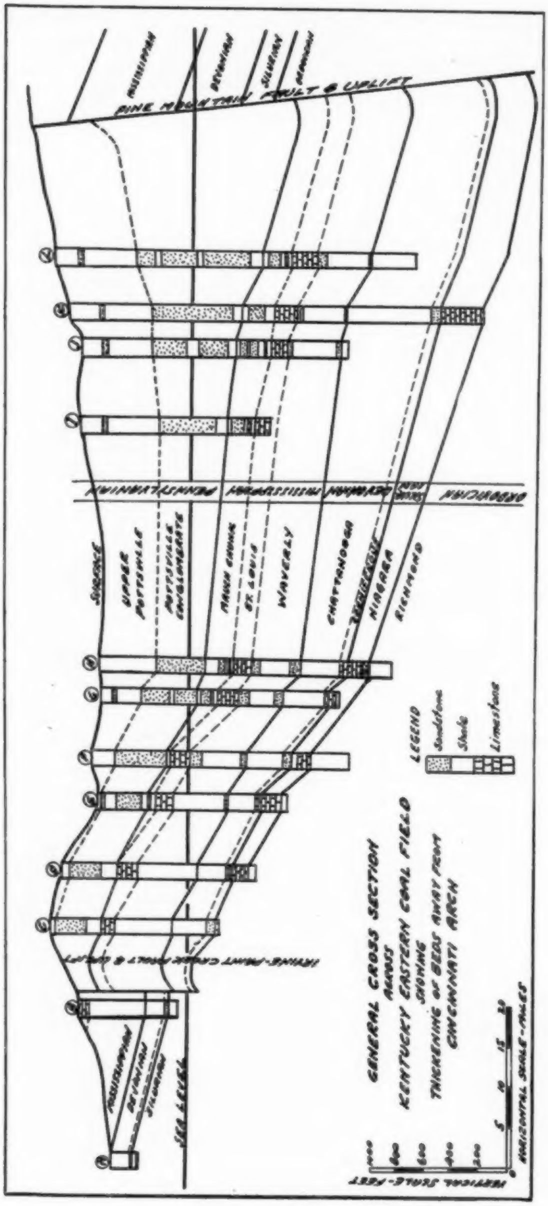
GENERAL CROSS SECTION
ACROSS
KENTUCKY EASTERN COAL FIELD
SHOWING
THICKENING OF BEDS AWAY FROM
CINCINNATI ARCH
PINE MOUNTAIN FAULT & UPLIFT
IRVINE-PAINT CREEK FAULT & UPLIFT
SEA LEVEL
SURFACE
UPPER POTTSVILLE
POTTSVILLE CONGLOMERATE
MAUCH CHUNK
ST. LOUIS
WAVERLY
CHATTANOOGA
NIAGARA
RICHMOND
PENNSYLVANIAN
MISSISSIPPIAN
DEVONIAN
ORDOVICIAN
LEGEND
Sandstone
Shale
Limestone
VERTICAL SCALE-FEET
HORIZONTAL SCALE-MILES

FIG. 3

MISSISSIPPIAN TIME

There seems to have been little or no movement of the arch during Mississippian time. The Berea sandstone was laid down on the shores of the early Waverly seas on the top of the Devonian. It extended almost to the eastern edge of Breathitt County. The deposition of the alternating shales and sandstones of the Waverly then took place, indicating an oscillating shore line. At the close of the Waverly a general submergence occurred and the St. Louis limestone was deposited. Both the Waverly and the St. Louis show a nearly even thickness across the region, indicating no important movement of the arch. Next in order, the Mauch Chunk beds were deposited upon the St. Louis. They indicate a period of alternating shallow water, deep water, and shore conditions. It was at the close of the Mauch Chunk that the principal uplift of the arch took place, and, judged from the basin produced, which was later filled with Pottsville conglomerate, this rise must have been nearly a thousand feet. A period of erosion then ensued which removed the Mauch Chunk from the arch down the flank as far as the eastern edge of Breathitt County, and eroded part of the St. Louis as well.

PENNSYLVANIAN TIME

The erosion of the Mauch Chunk from the crest of the arch and the removal at the same time of material from the Appalachian highland on the east furnished sediment for the Pottsville rivers and shallow seas to fill up the basin between these highlands. As stated before, this lower Pottsville formation is principally sandstone-conglomerate, with only a few coals and breaks of shale, indicating terrestrial conditions in the main; river and shore sands; shallow-water shales; and, here and there, swamps forming coal. This condition continued until 1,200 feet of this material had been deposited near the southern boundary of Kentucky and at least 100 feet near the crest of the arch, again producing flat topography. That the material at least for the upper part of the conglomerate came from the east is shown by the uniform angle of cross-bedding in the formation, the inclination being about 45° W. The upper Pottsville beds were next deposited. They represent conditions analogous to those during deposition of the conglomerate, except that swamp conditions and periods of shallow submergence predominate, with stream and shore deposits occurring only at intervals, producing a series of coals and shales interspersed with sandstones.

FINAL RISE OF THE ARCH

After deposition of the Pottsville sediments, at some period which cannot be accurately determined, the arch was again uplifted, tilting the Pottsville beds into their present inclination away from the axis (dip, 40 feet per mile), and increasing the inclination of all the lower beds. It is probable that at this same time was formed the series of north-south minor folds across the eastern coal field, of which folds the Paint Creek uplift in Magoffin and Johnson counties is the largest. The axes of these many minor folds are parallel to the axis of the arch. It is probable that these disturbances took place not long after the deposition of the upper Pottsville.

PINE MOUNTAIN FAULT AND IRVINE-PAINT CREEK FAULT

The disturbance which was responsible for the Pine Mountain and Irvine-Paint Creek faults was general from Pennsylvania as far west as Missouri, and, it is believed, occurred in Tertiary time. The faulting was preceded by a great pressure from the south, causing anticlinal folding with east-west axes. The overthrusting of the Pine Mountain anticline and the formation of the Irvine-Paint Creek fault (and to the north, the Sandy Hook fault) released this pressure. In areas where these Tertiary anticlinal axes cross the axes of the older north-south folds, formed with the last rise of the arch, doming has resulted in many places.

The nature of the Pine Mountain fault can be seen from the graphic cross-section. This structural feature began as a large anticlinal fold, which broke at the top and terminated in an overthrust fault having a throw of more than 2,000 feet.

The Irvine-Paint Creek fault has a vertical displacement of 200 feet. Faulting occurred low on the north flank of an anticlinal fold, resulting in a greatly increased dip of this flank of the anticline.

LEE-ESTILL-POWELL OIL FIELD

The stratigraphy and structure of the Lee-Estill-Powell field is shown by Figures 4, 5, and 6. This field produces an oil of about 38° Baumé from the Corniferous limestone at 1,000 feet. Production is from porous lenses in a magnesian limestone. There are three well-defined pay horizons, in about 100 feet of formation. The lower part may belong to the Silurian, though the division cannot be determined from well logs.

The field lies along the south flank of the Irvine-Paint Creek uplift. The field at Estill Furnace, which was drilled in 1915, lies to the south and on the upthrow side of a block fault. On the east, the Estill Furnace fault, which represents a break at the crest of the anticline, disappears; and the anticline assumes a normal shape, with a fault on the north flank. Scattered production occurs along the crest and down the south flank, but the prolific part of the field is in Lee County, near the junction of the county lines. Drilling here began in 1917. The best wells produce from the third "pay," the first and second "pays" in many places bearing water.

A comparison of the surface and subsurface folding may be made from Figures 4 and 5. The folds in the St. Louis are seen to be reflected in the Corniferous, but there are minor folds in the Corniferous not found in the surface beds. These minor folds suggest an old eroded topography of the Corniferous limestone rather than structural deformation.

The Lee-Estill-Powell field has produced a large part of Kentucky's production since 1916. Petroleum Exploration's properties in this field have produced to date an average of 3,500 barrels per acre and, it is estimated, will show an ultimate production of 5,000 barrels per acre.

The conclusion to be drawn as to the relation of production to folding in this field is that, while production is undoubtedly associated with major folding and

faulting, its location is entirely controlled by the character of the pay horizon, production occurring where porous lenses are found in the limestone.

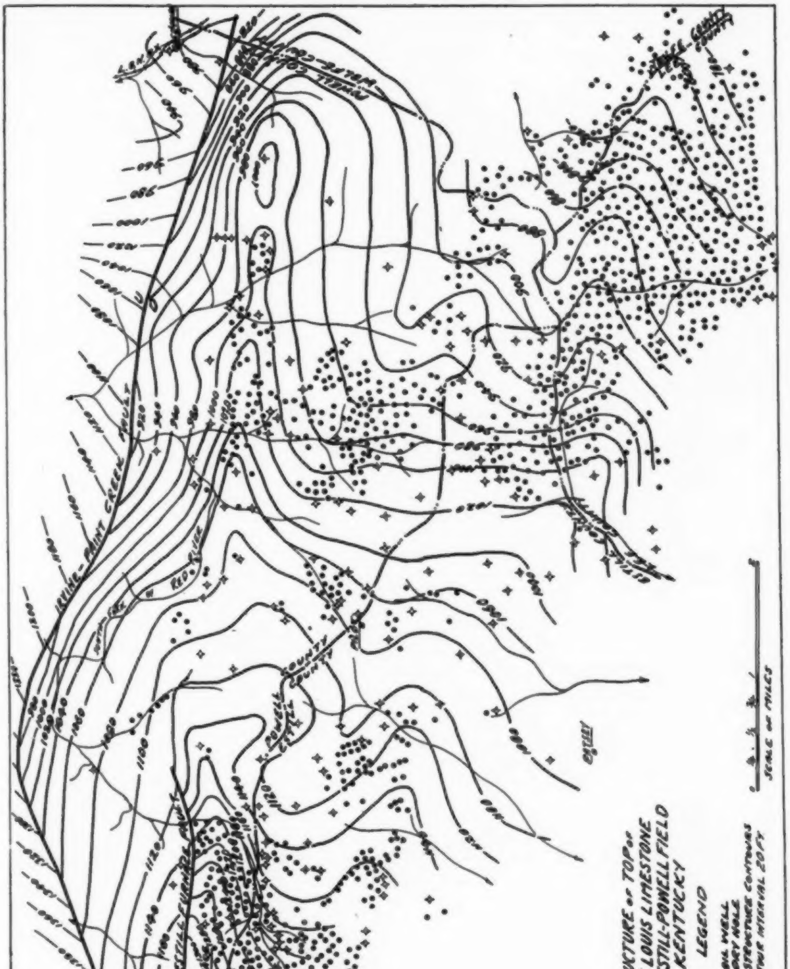

Fig. 4

CAMPTON OIL FIELD

The Campton field also lies along the Irvine-Paint Creek uplift, about 10 miles east of the Lee-Estill-Powell field. This field was drilled in 1905. Production is

from the Corniferous limestone at 1,200 feet. The two axes of folding mentioned before are very apparent in this field (Fig. 7). The Irvine-Paint Creek fault and anticline trend east and west, while the Stillwater fault and the minor axis of folding at Campton trend north and south. The crest of the main anticline at Campton is dry, production occurring well down on the south flank. Production also extends southward along the crest of the minor fold, giving the field a shoestring appearance. On the east side of the stillwater fault, production occurs along the crest

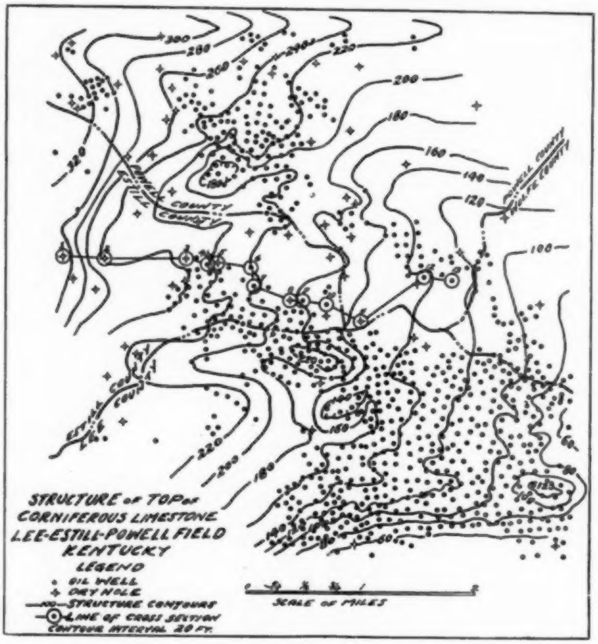

FIG. 5

of the main fold, after an interval of dry territory. The conclusion must again be drawn that the principal control of production in this field is the local character of the Corniferous limestone.

OWSLEY COUNTY GAS FIELD

The Owsley County gas field lies about 20 miles south of the Lee-Estill-Powell County oil field. The gas field as now outlined covers approximately 5 square miles and has about 30 scattered producing wells. The wells range in size from one to three million cubic feet, open-flow capacity, at 300 pounds initial rock pressure. The gas was utilized for two years in a carbon black plant, and on the basis of the pressure decline due to this production, the potential reserves of the field are placed

at about 20 billion cubic feet. The gas is not being marketed at present, though it is probable that it will be piped to the city of Lexington, 60 miles northwest.

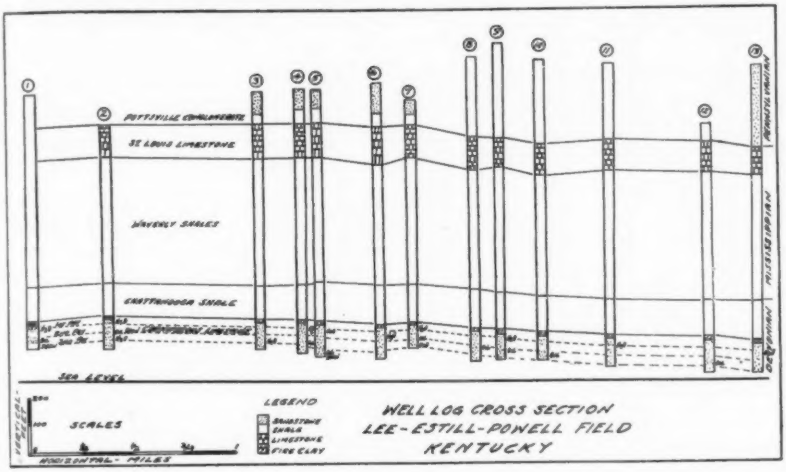

FIG. 6

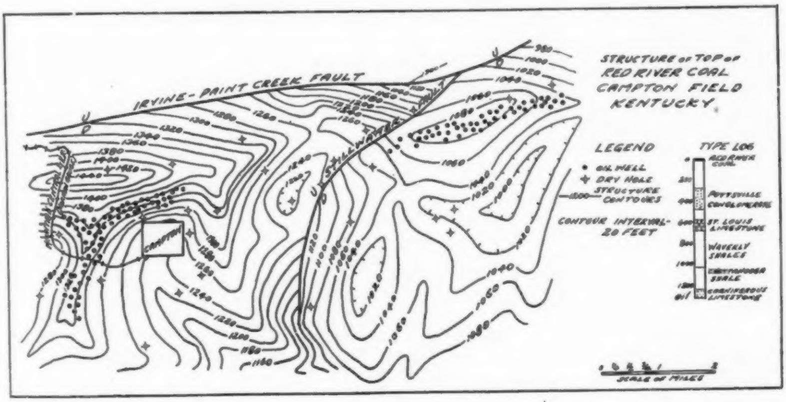

FIG. 7

North of the gas field, in Lee County, with dry territory intervening, there is a small oil field. Gas production is from the top of the Corniferous limestone at 1,400 feet, while the oil comes from the base of the same formation.

The structure of the producing horizon is shown in Figure 8. Although there is some doming and minor folding, and a suggestion of a terrace at the gas field, there

is no major fold, such as found at the other fields described; and the folding does not account for the localization of production. Production here seems to be controlled entirely by favorable conditions of porosity in the reservoir rocks.

CLAY COUNTY GAS FIELD

Twelve miles south of the Owsley County field there is a gas field which has not been fully defined, but in which enough wells have been drilled to demonstrate

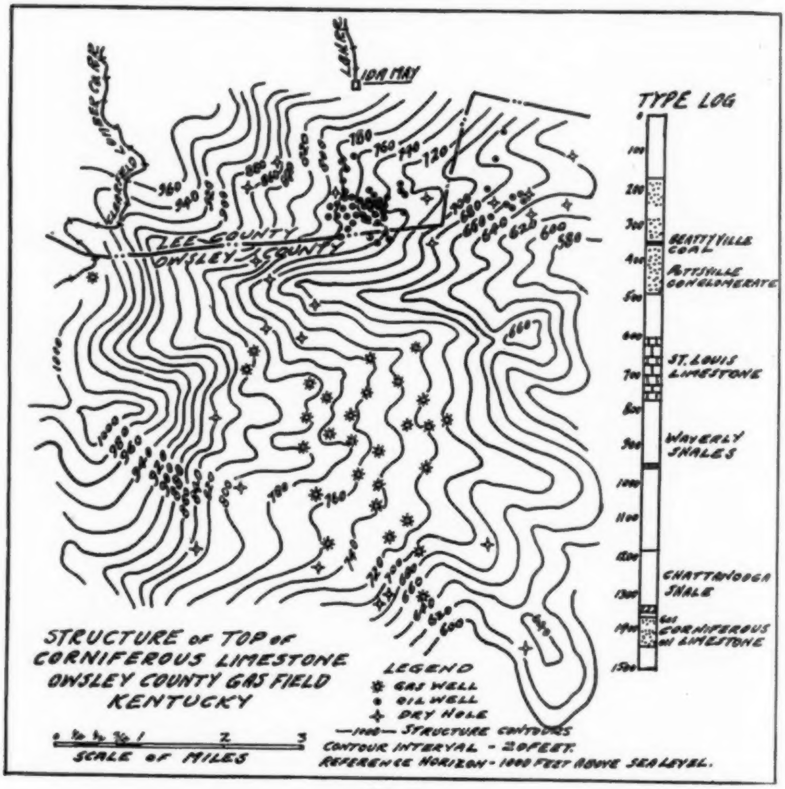

FIG. 8

that it is of commercial proportions. Wells are of about the same size and pressure as in the Owsley County field and produce from the same horizon at a depth of 1,600 feet. The territory which seems to be proved at present consists of about 4 square miles just south of the town of Oneida.

By referring to Figure 9, it can be seen that this gas field is associated with a major anticline showing the characteristic major and minor axes at right angles to

each other. Several good gas wells have been drilled on the north flank of the fold, near Burning Springs; but the commercial part of the field seems to be along the south flank of the minor fold, south of Oneida.

Production in this field seems to be associated with major folding but localized by the character of the producing horizon.

ELLIOTT COUNTY OIL FIELD

At the north end of the Paint Creek uplift there is a small oil field which is of small importance commercially but which is interesting structurally. The structure adjacent to this field is shown in Figure 10.

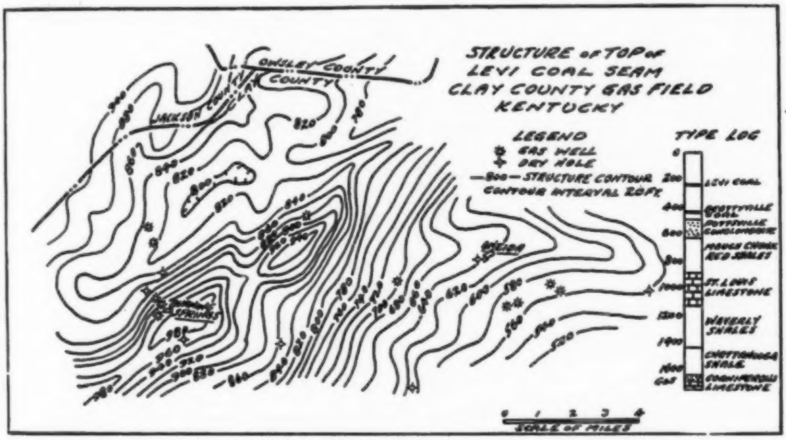

FIG. 9

The folding consists of a major axis and fault parallel to the Irvine-Paint Creek fault and a minor axis parallel to the Paint Creek uplift. Several wells have been drilled which have proved that the crest of the main fold is dry in all horizons. On the south flank of the minor fold, however, there are some small oil wells in the Wier sand and two gas wells in the Corniferous limestone.

The Elliott County field seems to be one where structural conditions are favorable but where sand conditions are not.

POSSIBILITIES OF THE EASTERN COAL FIELD AS A WHOLE

In studying the possibilities of obtaining new pools of oil and gas in the eastern coal field of Kentucky, reference should be made to Figure 2, which shows the relation of the present known pools to the major structural features and to the percentage of fixed carbon in the exposed Pennsylvanian coals. The theory that a definite relation exists between the percentage of fixed carbon in the coals of an

area and the character of any oil and gas deposits was advanced some years ago by David White. This theory has been applied to many of the principal oil and gas fields producing from coal-bearing areas, and has proved well founded.

METHOD OF CONSTRUCTING ISOCARB MAP

The contour lines connecting points of equal fixed-carbon content are termed "isocarbs." To establish these lines, analyses on all counties containing commercial coals in eastern Kentucky were collected from state survey reports and from operating coal companies. These analyses were grouped together by areas. Usually the watersheds of streams were taken as the units of area, as it is in this way that state reports are classified, and in addition, all mines are located along some principal drainage line. The percentage of fixed carbon in each analysis was computed

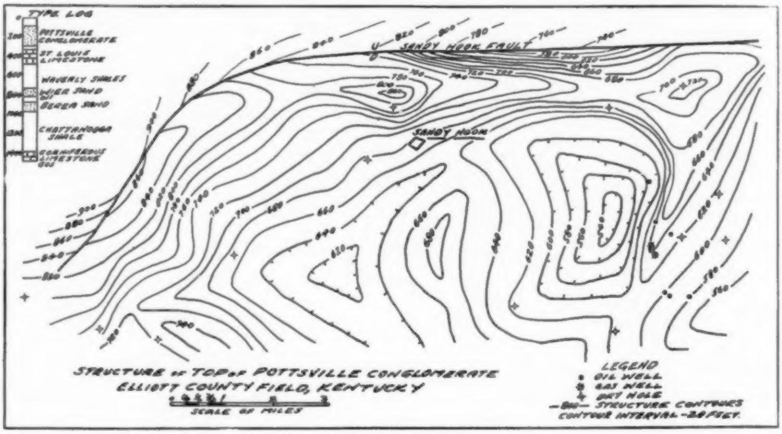

FIG. 10

on a pure-coal basis (moisture and ash excluded), and the results of each group were averaged and placed at the center of the group. Each percentage value placed on the map was therefore the average of 10 to 100 analyses. It was found necessary to discard all analyses of cannel coal as this grade runs about 20 per cent lower in fixed carbon than the bituminous coals. It was noticed, however, that the cannels showed a progression in fixed-carbon content, in the same direction and of about the same amount as the bituminous coals, and that no cannel existed in the areas of high-carbon bituminous coals.

INTERPRETATION OF THE MAP

It has been found generally true, in applying isocarbs to producing areas, that production below isocarb 55 is principally oil of low or medium gravity, that be-

tween isocarbs 55 and 60 production is of medium to high-gravity oil and gas, that between isocarbs 60 and 65 production is principally of gas or very high-gravity oil in shallow sands, and that above isocarb 65 very little or no commercial production of oil or gas may be expected. A study of the map of eastern Kentucky shows this region to follow these rules. The principal producing oil pools of this part of the state, the Corniferous lime pools of Estill, Lee, Wolfe, and Morgan counties, the Berea pools of Lawrence, and part of the Wier pool of Lawrence and Johnson counties, all lie below isocarb 60, and production is shallow, from a depth of 800 to 1,500 feet. The remainder of the Wier pool in Lawrence and Johnson counties, and the Magoffin County Wier pool, lie just above isocarb 60. This production, however, is a high-gravity oil from a shallow sand, depths ranging from 600 to 1,200 feet. It should also be stated that the big production is in Lawrence County, below isocarb 60, and that the Magoffin County pool, above isocarb 60, produces uniformly small wells from a tightly cemented sand. But one other occurrence of commercial oil is found above isocarb 60, namely, the Bosco pool in Floyd County. This oil has a gravity of 42° to 48° Baumé, and is produced from Pottsville sands at a depth of 800 feet. The carbon ratio here is 62, precluding the possibility of any production but a high-gravity oil from a shallow sand such as occurs in this pool. Other commercial occurrences above isocarb 60 are the gas pools of Martin, Johnson, Floyd, and Clay counties. Above isocarb 65 nothing has been found of importance, as is to be expected.

RELATION OF OIL AND GAS PRODUCTION TO MAJOR UPLIFTS

An interesting feature of the map of the eastern coal field is the relation borne by the oil and gas production and by the isocarbs to the major uplifts and faults. It will be noticed that the Irvine sand pools (Estill, Lee, Wolfe, and Morgan counties), which produce about 60 per cent of the oil produced in the state, lie along the flank of the Irvine-Paint Creek uplift, which parallels the Irvine-Paint Creek fault. It will be further noticed that the Wier pools of Lawrence, Johnson, and Magoffin counties (producing 30 per cent) lie along the axis of the Paint Creek uplift. Other production in eastern Kentucky is of very minor importance compared with these pools. The isocarbs are also controlled by the older folding, as shown by the position of isocarb 60, to include the Paint Creek uplift.

The close relation of production to uplift, here mentioned, bears out the theory that oil was formed during, and as the result of, folding, rather than having been formed prior to the fold and having subsequently migrated into it. It may be generally stated, therefore, that folding seems essential to the accumulation of oil in Eastern Kentucky, but that the degree of folding must not pass beyond a certain point (which point is first exceeded by the deeper sands) lest the hydrocarbons be changed to gas or lost. The most favorable formations for producing oil are those which are stratigraphically high, geologically young, and moderately folded.

FURTHER CONDITIONS AFFECTING THE ACCUMULATION OF OIL IN EASTERN KENTUCKY

In addition to the general conditions already discussed, the search for oil in eastern Kentucky is further affected by certain local conditions of the producing horizons, which are somewhat different for each of the several horizons.

THE CORNIFEROUS LIME AND CLINTON SANDS

These sands, of Devonian and Silurian age, respectively, belong to horizons geologically old; hence, can be expected to produce only high up on the side of the Cincinnati Arch where they have not been covered by any great depth of succeeding sediments in more recent times. In addition to this condition, the lithologic character of the horizons must be considered in prospecting. Both horizons are essentially impure, porous limestones containing irregular true sand inclusions. Therefore, although they afford good reservoirs where porous enough, the change in porosity is so abrupt in many places that an offset to a producing well may be dry. All the known Corniferous and Clinton (Niagara) pools of the state are lenticular in character. The largest lens is beneath the south end of the Lee-Estill-Powell field, in Lee County. Here a large, highly porous, true sand inclusion in the Corniferous is encountered, which has produced some really remarkable wells. It can be generally stated, regarding the Corniferous and Clinton, that production will occur somewhere upon the flanks of the major folds (generally not on the top, probably because folding here has been more intense and has tightened the sand) and that production will be controlled by structure in so far as the sand continues with even porosity, but that the principal control of production will be the location of the porous streaks in the limestone, or the position of the included sand lenses.

THE WIER SAND

The Wier sand, which ranks next to the Corniferous as a prolific producer of oil in eastern Kentucky, is a true sandstone, very fine-grained, and lenticular in character. It does not extend as a continuous sand any great distance beyond the limits of the Paint Creek uplift. Outside these boundaries, the sand is broken by several beds of shale, and fails to produce on minor structures surrounding the Paint Creek uplift. Most of the production occurs in the top bed of the Wier, above the first shale break, where this top sand is thick. When it thins to less than 5 feet, production ceases. Some wells are obtained in the lower Wier, but they are never large. Several explanations may be offered for these conditions. It is possible, because of the fine texture of the sand, that a great thickness of pay is required to furnish large production; that it required a major uplift, such as the Paint Creek uplift, to generate the oil; that the source rock is lacking in outlying structures; or that the sand is too tight in outlying areas to form a good reservoir. A careful study of the Wier sand from well logs and sand samples would probably determine the true explanation for the localization of production in this sand.

THE BEREA SAND

The Berea sand is a source of commercial production in Lawrence County, but tests in other localities have been unsuccessful in this horizon. This bed is recognized to be a non-water-bearing, gritty sandstone with great variations in porosity. Production seems to be synclinal in general, but not always. Accumulation is controlled to a great extent by the porosity. This horizon has some possibilities in the northeastern counties, but its spotted character makes it a difficult horizon to prospect. It will produce nothing but gas above isocarb 60, because of its depth above this contour.

POSSIBLE NEW OIL AND GAS TERRITORY OF EASTERN KENTUCKY

It is now possible, by considering the facts brought out, to list the counties of eastern Kentucky according to their possibilities as areas of probable oil production, of probable gas production, or as dry areas.

COUNTIES FAVORABLY LOCATED FOR OIL

In addition to the parts of Estill, Lee, Wolfe, Morgan, Lawrence, Johnson, and Magoffin counties already mentioned as productive, there are several counties which are not condemned as oil-producers with the information available at the present time. If the Irvine-Paint Creek uplift extends from Estill County west into Jackson and Rockcastle counties, as seems to be the fact, production of oil from lenses in the Corniferous "lime" is quite probable. These two counties, therefore, seem to merit further investigation. Lewis, Greenup, and Boyd counties have possibilities of oil production provided they are crossed by folds of sufficient size to induce the formation of oil from the source rock. As these counties lie below the 55 isocarb, they should produce but little gas. The Corniferous and Clinton offer possibilities in Lewis County; but the Berea is probably the only sand offering possibilities in Greenup and Boyd counties, because of the depth of the Corniferous and Clinton. Owing to the uncertain nature of the Berea, the potential value of Boyd and Greenup counties is somewhat doubtful.

COUNTIES FAVORABLY LOCATED FOR GAS BUT NOT FOR OIL

All territory between isocarbs 60 and 65 may be considered potential gas territory, provided the sands are not so deep as to have the effect of raising the content above 65. This territory includes Elliott, Morgan, Menifee, Magoffin, Floyd, Knott, Breathitt, Owsley, Clay, Whitley, Laurel, Knox, Leslie, Perry, Letcher, and Pike counties. Any considerable uplift should produce gas in these counties in sands which are reasonably shallow. Little oil can be expected in this area, except Pottsville oil or extensions of the Wier pool of Lawrence-Johnson-Magoffin counties. As already stated, the Pottsville oil area cannot be profitably prospected.

COUNTIES FROM WHICH NO COMMERCIAL PRODUCTION CAN BE EXPECTED

It is useless to prospect for oil or gas in the counties lying above isocarb 65, which include Bell, Harlan, and the southern parts of Whitley, Leslie, and Pike counties. Prospecting in deep horizons is useless as isocarb 65 is approached. As Madison, Clark, Montgomery, Bath, and Fleming counties lie for the most part west of the outcrop of all the producing sands, they need not be considered. Powell, Rowan, and Carter counties do not contain folds of sufficient size to influence the formation or accumulation of oil.

It is evident from the above study of possibilities of eastern Kentucky that the discovery of other large oil pools is very improbable. The areas favorable to oil production are very limited, and the lenticular character of the sands and close relation to major folding reduce this territory to an extremely small acreage.

The prospect for new gas fields is somewhat brighter, but a limited market will hamper extensive gas development for a long time to come.

THE PETROLEUM RESOURCES OF RUSSIA[1]

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ABSTRACT

Indications of oil and gas occur in European Russia in the northern and central parts of the great Russian Platform, whose gently folded and faulted structure should encourage drilling. Commercial production, however, has been confined almost entirely to the downfolded or downfaulted basins of the south, the Black Sea Basin and the Caspian Basin, as well as the Kura and Kutais basins of Transcaucasia.

Of the vast territory of Asiatic Russia, the most promising part for future oil supply seems to be the downfolded or downfaulted basins of Russian Central Asia, filled with folded marine Jurassic, Cretaceous, and Tertiary strata; and the highly folded Tertiary beds of the east coast of northern Sakhalin. Some possibilities of oil or gas may exist in the broad plain between the Ural Mountains and Yenisei River, but these remain to be demonstrated. Oil has already been produced commercially in the Emba Basin north of the Caspian Sea, in the Transcaspian Basin east of the Caspian Sea, in the Ferghana Basin of eastern Turkestan, and recently in northern Sakhalin.

INTRODUCTION

It would be difficult in this brief space to discuss with any pretense to completeness the petroleum resources of a country covering 8,200,000 square miles or more than a seventh of the land area of the earth. Obviously, in such a discussion only the outstanding facts of its geology, its known oil fields, and its future possibilities can be treated. Nevertheless because of its very size, its past production, and its promises of future stores of oil and gas, if for no other reason, Russia deserves our study and our interest.

Until recent years, our knowledge of the general geology of European Russia has been rather scanty. This has been due especially to the scattered references in Russian literature, hardly accessible to American and western European students, even if they knew the language. Much regarding the fundamental structure of Russia established by Karpinski, Chernyshev, and other Russian geologists, was summarized by Suess in *The Face of the Earth;* nevertheless many questions were unsolved, much information was lacking, and much that was assumed as correct has since proved to be erroneous.

In the last decade Russian geologists have brought to light many facts, but until recently no attempt has been made to work these up into a unified picture. The first attempts at a synthesis of Russian geology by Mikhailovski and Tetjaev were incomplete and possibly not well planned.

[1] Read before the Association at the New York meeting, November 15, 1926. Manuscript received by the editor, November 17, 1926. Published by permission of the director, U. S. Bureau of Mines.

[2] Introduced by Carroll H. Wegemann.

After a work of years Arkhangelskii has succeeded in formulating a plan which works up all the new material logically and shows the basic traits of the architecture of eastern Europe in a light not previously known. This plan, as summarized by Von Bubnoff, forms the basis of the present study.

In the same way Borissiak has summarized the geology of Siberia. Our knowledge of Russian central Asia still rests largely on the studies of Russian geologists of the last century and on Leuchs' regional study of 1916.

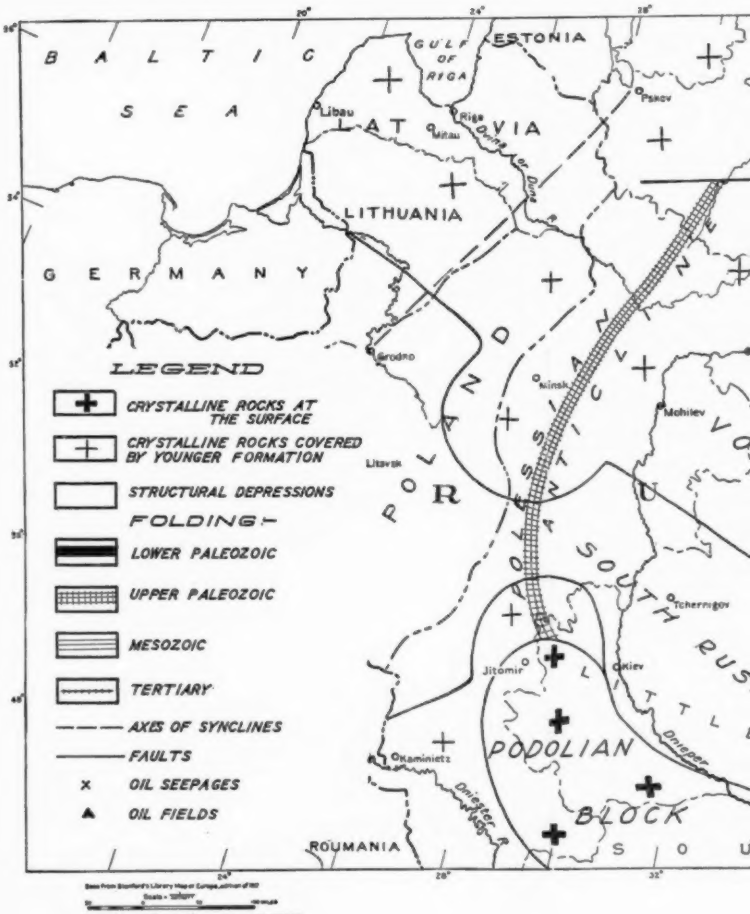
In the more specialized field of petroleum geology a mass of material has been written by Russian geologists, for the most part in their own difficult and little-understood language. This has been summarized in English by Beeby Thompson, Redwood, Adassievich, Huntley, Madgwick, Calder, Holiday, De Hautpick, and others, and in Germany chiefly by Engler and Höfer and Von Stahl, as well as by some writers in French and Italian. It is the task of this paper to present a brief and selected summary of the results of these investigators and compilers.

A. RUSSIA IN EUROPE

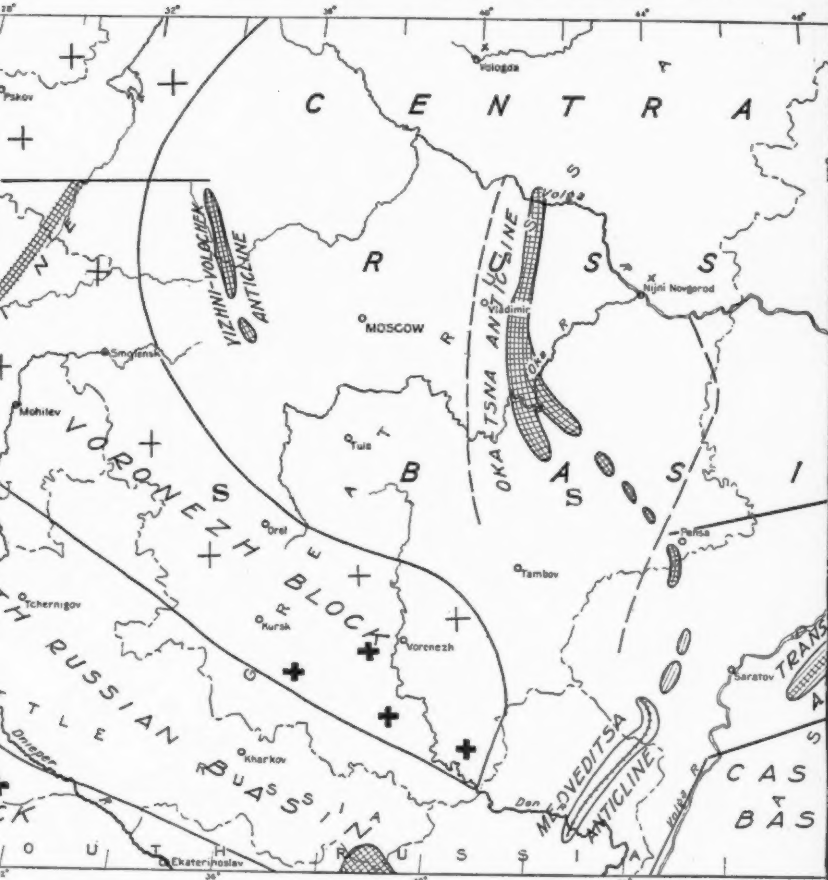
European Russia west of the Ural Mountains and north of the Caucasus Mountains, is chiefly a low plain of uniformly, even monotonously, level surface. Its geologic structure is simple. Vast areas of Permian and Mesozoic beds lie almost horizontally upon older Paleozoic strata which are scarcely more disturbed, and are concealed in turn beneath horizontal Tertiary and Recent deposits, especially in the downfaulted or downflexed basins of the south. The flat-lying Paleozoic and Mesozoic sediments of this so-called Russian Table or Platform rest upon a foundation of crystalline schist which comes to or near the surface in Finland, Karelia, and the Kola Peninsula and disappears south of the Gulf of Finland beneath a platform of little-disturbed Cambrian, Ordovician, and Silurian beds. In southern Russia, in the Azov-Podolian block, similar crystalline rocks are brought near the surface. The true southern margin of the Russian Table, however, occurs in the Governments of Kursk and Voronezh, where the granite of the Voronezh block outcrops locally, as at Pavlovsk, beneath Middle Devonian strata.

The Russian Platform may be divided into several large units which differ in structure, in the character of their beds, and in geologic history. It is bordered by ranges of folded rocks, the Ural and Timan mountains, built chiefly of folded Paleozoic strata, in the east; and the Caucasus and Crimean mountains in the south, composed of ancient crystalline and highly disturbed Paleozoic and Mesozoic rocks.

Indications of oil and gas occur in both the north and the center of the Russian Platform, whose gently folded and faulted structure should encourage drilling. Commercial production, however, has been confined almost entirely to the downfaulted or downfolded basins of the south, the Black Sea Basin and the Caspian Basin, as well as the Kura and Kutais basins of Transcaucasia.


BALTIC SEA
GULF OF RIGA
ESTONIA
LATVIA
LITHUANIA
GERMANY
POLAND
ROUMANIA
Libau
Riga
Mitau
Pskov
Grodno
Minsk
Mohilev
Litovsk
Tchernigov
Kiev
Jitomir
Kaminietz
PODOLIAN BLOCK
SOUTH RUSSIA
Dnieper
Dniester R.
LEGEND
CRYSTALLINE ROCKS AT THE SURFACE
CRYSTALLINE ROCKS COVERED BY YOUNGER FORMATION
STRUCTURAL DEPRESSIONS
FOLDING:-
LOWER PALEOZOIC
UPPER PALEOZOIC
MESOZOIC
TERTIARY
AXES OF SYNCLINES
FAULTS
OIL SEEPAGES
OIL FIELDS

STRUCTURAL MAP OF CENTRAL RUSSIA
(AFTER VON BUBNOFF)



NTRAL RUSSIA
BNOFF)

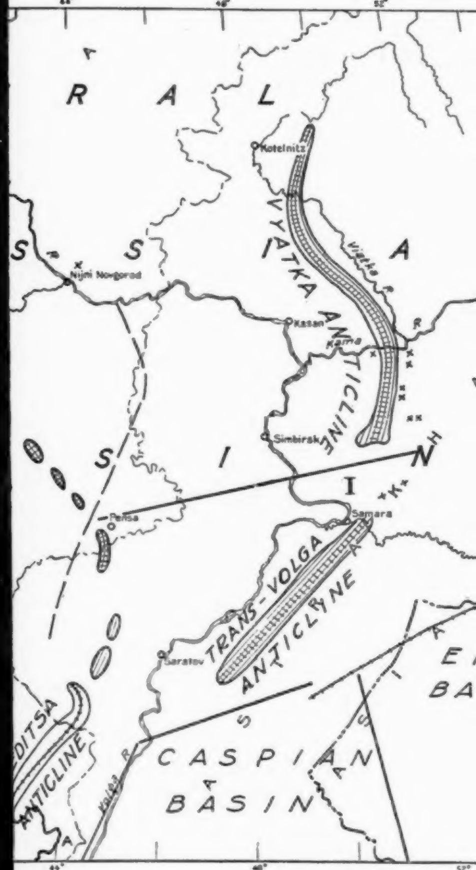
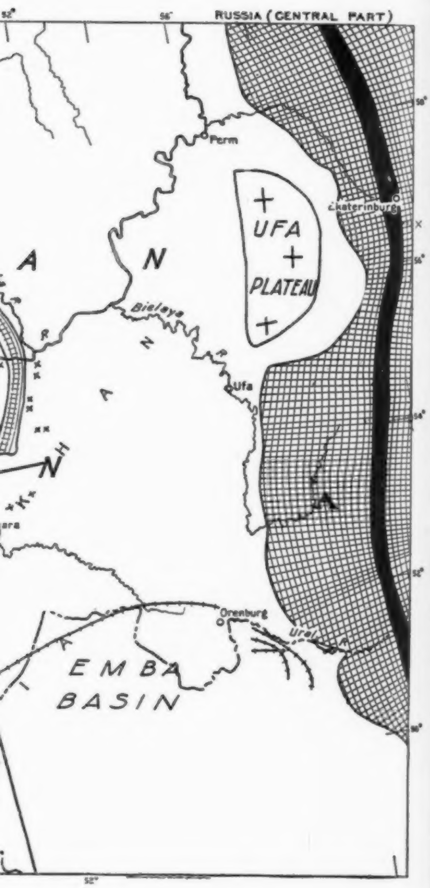


PLATE 4



RUSSIA (CENTRAL PART)
Perm
Ekaterinburg
UFA
PLATEAU
A
N
Bielaya
R
Ufa
N
Orenburg
Ural
R
EMBA
BASIN

THE RUSSIAN PLATFORM

The structure of the northern third of the Russian Platform (Fig. 1) is still imperfectly known. At several places in the far north, as in Andomer Mountain on Lake Onega, on Onega River, and on the northern Dvina, flat folds trending northeastward occur in the Devonian beds.

Oil sands are reported to occur in the Permian near the town of Vologda, and along Sukhona River. These have been little prospected and are entirely undeveloped.

Along the eastern flanks of the Timan Range, in the Governments of Archangel and Vologda, indications of petroleum have been reported to occur along a line of 158 miles from the Tsilmamilva, a tributary of Petchora River southeastward beyond the Ukhta in the Government of Vologda, in the upper Devonian series, which contains beds of fairly rich oil shale in an area of more than 300 square miles.

Along Ukhta River the faulted Devonian rocks form a broad, flat anticline trending north-northwest to south-southeast. The oil occurs in sand beds underlying the oil shale. Wells drilled in this field in 1913, 1918, and 1919, obtained a little oil with a specific gravity of 29.1° A.P.I., yielding 12 per cent of gasoline. The oil does not flow freely, but gathers slowly in the wells.

The center of the Russian Table (Plate 4) forms a broad, shallow basin widening to the east. It may be divided into three structural elements which descend step-like toward the east: the Polessian or Scythian Anticline in the west, the flat Moscow Basin in the center, and the deeper East Russian Depression in the east.

Along the western boundary of central Russia the Devonian beds form the so-called Polessian or Scythian Anticline, which trends northward and northeastward, and dips northward under the basin of Cretaceous, lower Tertiary, and Pleistocene beds, which is occupied by the Pripiat Swamp. North of the swamp, the Devonian axis rises again, and near Minsk, as well as on the Lovat south of Novgorod, even Cambrian, Ordovician, and Silurian beds appear. It is not definitely known how far to the north the fold continues.

On the west side of the Polessian Anticline, asphalt is reported to exude from Devonian rocks on the north side of Lake Escha, Rositen district, Government of Vitebsk; and ozokerite, or a kindred substance, occurs in the peat bogs of Kaluga. No attempt has been made to prospect or develop this occurrence.

The interior of the broad Moscow Basin is crossed by flat swells of upper Paleozoic strata, in places 25 miles wide and hundreds of miles long, which in the north trend north-south and then bend to the southeast. Three principal anticlines can be distinguished: those of Vizhni Volochek-Novotorshok, Oka-Tsna, and Vyatka, separated by the flat Ryazan-Kostroma and Simbirsk-Saratov basins filled with Mesozoic beds.

On the east flank of the Oka-Tsna Anticline an oil seepage is reported at the

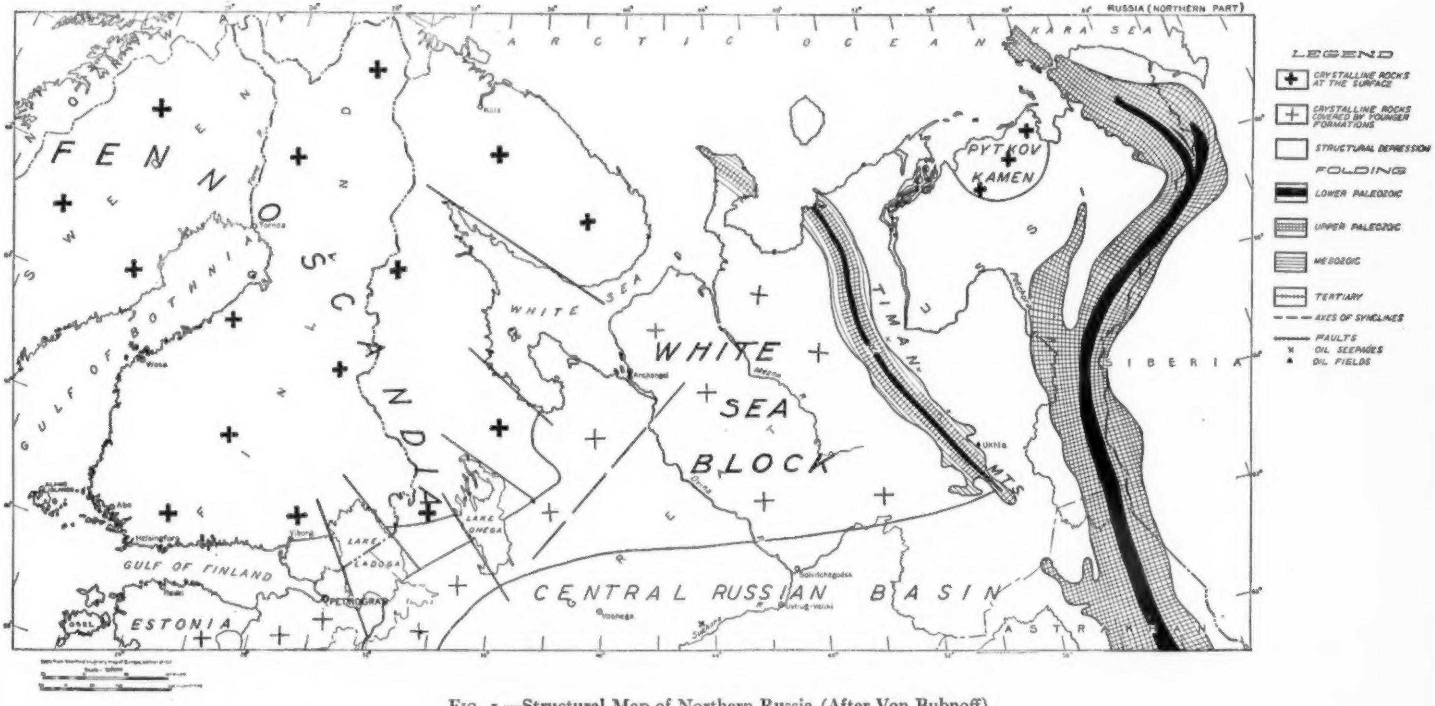


FIG. 1.—Structural Map of Northern Russia (After Von Bubnoff)

contact of the Triassic and the Permian at Semenova on the Suktanka, north-northeast of Nizhnyi Novgorod, associated with sulphur and gypsum. This occurrence has not been prospected.

On the east flank of the Vyatka Anticline, in the Governments of Samara, Simbirsk, and Kazan, oil seeps form and impregnate sandstone beds in the Lower Carboniferous and the Permian, from Syukieef on the Volga and Lower Karmalka on the Sheshma to Kamishla on the Sok and Upper Orlianka on the Kinel. The "mother-rock" is believed to occur in the Devonian. Gas is reported at Novo Uzensk, in Samara. Seams of oil shale in the Upper Jurassic occur over wide areas.

Except for a little ineffective drilling, between 1860 and 1870, no effort has been made to prospect or develop any oil that might be present. The Jurassic oil shale has been worked at Kashpur, 5 miles south of Syzran.

The Vyatka Anticline is cut off abruptly on the south by a zone of transverse faults and flexures which trends generally east-northeast to west-southwest. In the southern part of the central Russian Basin are two anticlines trending northeast-southwest: the Trans-Volga Anticline, a flat arch of Upper Carboniferous and Permian beds, and the Medveditza Anticline, composed of Paleozoic to lower Tertiary beds.

Between the Vyatka Anticline and the Ural Mountains lies the broad East Russian Depression, filled with Carboniferous, Permian, and Triassic beds. Little is known in detail of its internal structure. In the Plateau of Ufa the Carboniferous and Permian beds appear to form only a thin cover over a block of ancient crystalline rocks.

In the Government of Perm, bands of bituminous shale occur in the Lower Carboniferous, especially on the Kosva, about 22 miles south of Alexandrovsk, and on the railway 33 miles farther south and 14 miles north of Chusov. Asphalt occurs in Permian sandstone at Subovka, and exudations of oil at Shakitau—both in the Sterlitamak district of Ufa.

No serious effort has been made to develop these occurrences.

THE BLACK SEA BASIN

On the south the Azov-Podolian block is cut off by an east-west fault. The Black Sea Basin (Fig. 2) which succeeds to the south is filled with Upper Cretaceous and Tertiary beds, generally flat-lying, but folded in places along east-west lines, especially in the south along the northern margins of the Yaila Mountains of the Crimea and of the Caucasus Mountains.

The Crimean district.—In the Crimea, petroleum seeps from the folded Oligocene and Miocene beds at Zamorsk on the coast of the Sea of Azov; at Misir and Karalar near Chokrak; in the mud-volcanoes of Bulganak, Enikale, and Jerjaff near Kertch; at Temesh, Karmish, Keletcha, Jermai Kashik, and Chuburtma Sart in the interior of the peninsula; and at Kashelar, Kop Kotchegan, and Chongelek in the southern hill range of the Kertch Peninsula.

Drilling was begun in 1860 at Chongelek, 111 miles south of Kertch, and at

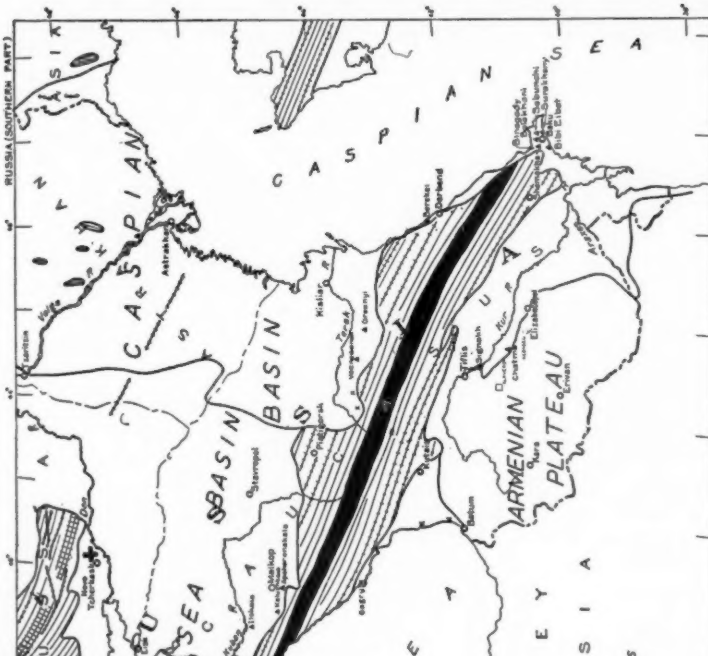


FIG. 2.—Structure Map of Southern Russia (After Von Bubnoff)

other places south and west of Kertch. Oil was found in small quantities, and a few short-lived gushers were struck. No great yield has yet been obtained from the Crimea.

The Kuban district.—East of the Straits of Kertch, the Taman Peninsula is formed of a series of sharp anticlinal ridges, rising between swampy plains. Along these anticlinal ridges, mud volcanoes are plentiful; and the plains are covered largely with the mud which they have ejected. Petroleum constantly accompanies the mud, but only a small yield of high-grade oil has been obtained in the Miocene, although many wells have been drilled on the peninsula since 1864. Apparently, however, clay predominates in the Tertiary beds; and porous beds suitable for reservoirs are few.

In the northern foothills of the Caucasus the slightly disturbed Tertiary rocks dip northward away from the highly disturbed Cretaceous hills upon which they lie unconformably.

A zone of oil and gas seepages extends southeastward more than 120 miles, with an average breadth of 4½ miles from the Taman Peninsula to Neftianaia-Shirvanskaia, southeast of Maikop. In the province of Stavropol, rich seepages were reported near Karras and Nicolaevsk, north of Piatigorsk. Ozokerite is reported as found near Krasnodar (Ekaterinodar) and at Kalatchin, 37 miles southeast of Maikop; its occurrence in the Khadijin district is well established.

For more than 65 years, drilling has produced oil at Apsheronskaia, Neftianaia, and Shirvanskaia, 10 to 12 miles south and southwest of Maikop; at Kaluzhkaia, 32 miles west-southwest of Maikop; near Krymskaia, 19 miles north-northeast of Novorossiyisk; and formerly at Ilskaia, south of Krasnodar (Ekaterinodar). The oil occurs not on anticlines, but on monoclines, evidently trapped in lens-shaped deposits of sand in clay formations or along unconformities.

Gas has been struck near Stavropol and at Eisk.

In the Maikop field the main oil accumulations occur in an upper Oligocene or lower Miocene conglomerate which fills former valleys eroded in the top of the middle Oligocene foraminiferal clay and marl, and in sand lenses in the middle and upper Miocene clay. In general the Miocene of the Kuban district contains fewer sand beds than that of the Terek district or of the Apsheron Peninsula.

At Ilskaia the upper Oligocene and lower Miocene sand lenses gave light oil, and a heavier oil came from an upper Miocene dolomite.

At Maikop oil from the lower conglomerate has a gravity of 37° A.P.I., as compared with 19° A.P.I. for that in the higher sands. At Kaluzhkaia and Krymskaia oil of 29° to 37° A.P.I. has been obtained from the lower formations and of 16° to 21.5° A.P.I. from the upper formations.

In the refineries at Krasnodar (Ekaterinodar), where the crude oils, both of the entire Kuban districts and of the Crimea, are distilled, 19.5 to 20.6 per cent of gasoline, 16.6 to 26.7 per cent of kerosene, and 52.5 to 63.7 per cent of fuel oil are obtained.

THE CASPIAN BASIN

The low-lying Caspian Basin, filled with Tertiary beds almost entirely covered by Quaternary deposits, is bounded principally by faults. Within the basin the structure of the concealed Tertiary is difficult to determine. Geologic studies around Elton, Bogdi, Baskunchak, and Inder lakes north of the Caspian Sea indicate that the Tertiary beds are broken by four distinct lines of faulting and folding: west-northwest to east-southeast, north-northwest to south-southeast, east-northeast to west-southwest, and north-northeast to south-southwest. Little is known in detail of the structure of the basin north of the Caspian Sea, and practically no prospecting has been done to test the possibilities of oil or gas.

The Terek district.—North of the Caucasus Mountains in the Terek Province, the hill ranges are composed of Miocene and Pliocene beds folded parallel to the Caucasus Mountains. Chief of these are the Terek, Groznyi, and Sunja ranges. The Black Hills Range, south of the Sunja Valley, is a monocline dipping strongly to the north.

A line of seepages may be traced along the south side of the Groznyi Hill Range. A second line extends along both sides of the Terek Range. A third line of seepages runs along the north flank of the Black Hills.

Drilling on the north flank of the Groznyi Hills has produced oil. In the Old Groznyi field, oil is produced on a faulted, asymmetric anticline, steep on the north side, in which the Pliocene surrounds an elongated compressed dome of Miocene beds. Oil is obtained from seven sand beds in the middle Miocene shale and sandy clay formation 1,200 feet thick. The oil field, 11.5 miles long and 0.62 miles wide, is well defined and offers apparently no scope for new developments. Five miles southeast, in the New Groznyi field, 53 per cent of the production of Terek Province is obtained, also on an asymmetric anticline evidently a continuation of the Old Groznyi fold.

Ten miles east of the Old Groznyi field, a field has been developed at Bellik on a more symmetrical anticline with a core of Miocene surrounded by Pliocene beds.

At Voznesensk, on the Terek Anticline, which resembles that of Old Groznyi, one well is said to be producing.

The oil produced in the Groznyi and neighboring fields varies from 21° to 28.5° A.P.I., and is rich in paraffin. In the Groznyi refineries 1 to 7.9 per cent of gasoline, 17.6 to 25.1 per cent of kerosene, 0.1 to 3.2 per cent of gas oil, 2.4 to 8.6 per cent of lubricating oil, and 59.2 to 78.3 per cent of fuel oil are obtained.

The Daghestan district.—In Daghestan a line of seepages extends in the foothills of the Caucasus from 10 miles south of Chiryurt to Berekei, 16 miles north of Derbent. Oil issues from mud volcanoes at Khosh Menzel, 10 miles south of Derbent; and gas near Derbent.

The surface rocks are folded parallel to the coast, but, as these rest unconformably upon lower beds with a different strike, the anticlinal and synclinal axes of the overlying series furnish no clue to the structure of the deeper beds.

Deep wells have been drilled at several points, but no great yield has been obtained, probably because of unfavorable structural conditions. At Berekei, north of Derbent, on a much-faulted anticline, oil of 31.5° A.P.I. was obtained from 1893 to 1915, from beds of Eocene (?) age. The oil sands were flooded by hot sulphurous water, and the field was abandoned, although a few wells continued to yield several years longer.

The Baku district.—The Caucasus Mountains are cut off abruptly on the southeast, and are succeeded by the low hilly, triangular Apsheron Peninsula, built chiefly of Oligocene, Miocene, Pliocene, and Quaternary beds. The general trend of folding is northwest-southeast, parallel to the Caucasus Mountains, but this structure is complicated by minor folding in other directions. Accordingly, on the Apsheron Peninsula, there are four directions of folding with directions northwest-southeast, north-south, east-west, and north-northeast to south-southwest. These folds change direction and merge into each other, especially where faulted along the strike. The developed fields lie on folds around the margin of a synclinal basin, in which lies the town of Baku.

The upturned and denuded edges of the Oligocene are largely covered by Miocene, Pliocene, and later deposits, which have also been somewhat disturbed. As the movements which affected the upper Tertiary rocks were in a direction oblique to the older folds, the folds in the upper Tertiary give no clue to the structure of the much more disturbed beds below. As the formations subject to such diverse compression consisted primarily of wedge-shaped beds and lenses of varying extent and compactness, some more resistant than others, the resulting structure is accordingly quite complex. Consequently, wells within a few yards of each other penetrate very different sequences of strata, striking oil sands wholly disconnected and differing in depth, water pressure, and other conditions.

The lower Tertiary rocks through the whole peninsula are mainly clay, which contains abundant organic material for the formation of oil. Both the lower Miocene and the Oligocene yield seepages and contain mud volcanoes, for which Baku is famous. They are, however, deficient in sands or other porous rocks, which can form good oil-containers. In the upper Tertiary of the Apsheron Peninsula, however, are thick masses of sand in the so-called "continental" and "freshwater" beds of the lower Pliocene, capped by thick upper Pliocene clay which effectively seals them although much faulting has taken place.

The chief oil-producing formation of the Apsheron Peninsula consists of more than 4,200 feet of alternating clay and sand with intermediate layers of clayey sand and sandy clay, of Pliocene, or according to some geologists, of upper Miocene age. The beds thin out and pinch out towards the sides, are much disturbed, and contain few fossils, so that the exact determination of the age and the detailed study of the formation are difficult. The beds are variously believed to be of deep sea, inshore, or continental origin, or, more recently, of delta origin.

The sandstones range from hard rock to sand so loose as to be brought up in large quantities with the oil. Masses of compact rock are occasionally hurled forth

to a height of more than 800 feet by the gushers or by the powerful bursts of gas set free, and the drilling tools are frequently ejected from the wells.

Yields from the upper Pliocene and younger deposits, which unconformably overlie the older series, are believed to be due to upward infiltration from the Miocene and lower Pliocene. Wildcatting in the underlying formations has given small quantities of oil in the lower Miocene and in the lower Oligocene, but not in the intervening strata, although many seepages are known from the lower Miocene and in the western hills from the lower Oligocene.

Oil is found at widely different depths, even in closely adjacent wells; and the yield usually increases proportionally with the depth. As the beds are greatly dislocated little or no hydrostatic connection exists between the productive sands, each of which constitutes a practically independent source of supply.

Improvement in drilling apparatus and in technical skill, stimulated by indications that the uppermost oil sands were being exhausted, has resulted in constant increase in the depth at which oil has been reached. In 1862, 70 feet was the greatest depth reached; in 1873 this had been extended to 200 feet; in 1884, to 500 feet; in 1896, to 1,450 feet; and many recent wells have exceeded 2,000 feet.

Between 1892 and 1896, new wells yielded 600 barrels a day, and the average for all wells was more than 200 barrels a day. In 1909 the average well yielded 82 barrels a day. In 1913 the average output per well had decreased to 49.4 barrels a day, and in 1924 to 44.5 barrels.

Oil has been produced commercially principally north of Baku on the long, wide, faulted Balakhany-Sabunchi-Ramany Anticline trending generally east-west and plunging to the southeast; east of Baku on the broad, flat Surakhany Anticline trending north-south; south of Baku on minor domes on the broad, faulted Bibi-Eibat Anticline, trending northwest-southeast, and plunging to the northwest; north of Baku on the broad, faulted Binagady Anticline, trending east-west, and plunging to the east. A smaller production is obtained at Baladjari, north of Baku; at Khurdalan, northwest of Baku; and at Puta on faulted anticlines; and at Atashka, southwest of Baku, Kala, east of Surakhany, and Zykh, south of Surakhany, on flat folds.

On Holy Island (Sviatoi Ostrov), off the east end of the Apsheron Peninsula, oil is produced from sand beds in the Miocene, on an elongated and faulted dome somewhat overturned and even overthrust, trending northwest-southeast.

Two grades of oil are produced on the Apsheron Peninsula, a light oil varying from 29.3° to 40° A.P.I., chiefly at Ramany, Surakhany, and Bibi-Eibat; and a heavy oil ranging from 19.7° to 23.5° A.P.I., chiefly at Binagady, Balakhany, and Holy Island. At Surakhany a "white oil" of 52.5° A.P.I. and an "amber oil" of 50.9° A.P.I. are obtained from shallow wells in the Pliocene, evidently derived from underlying beds and naturally filtered during its migration.

At the Baku refineries the different oils yield on an average 6.6 to 7.7 per cent of gasoline, 4.7 to 4.8 per cent of kerosene, 7.7 to 8.3 per cent of engine fuel oil, and 74.2 to 79.0 per cent of residual fuel oil.

THE KURA BASIN

In Azerbaijan, between the high Caucasus Range on the north and the edge of the Armenian Plateau on the south, extends the lowland of the Kura Valley. Structurally this is a trough bounded by faults filled with completely folded and faulted upper Tertiary beds largely covered by Quarternary alluvium.

East of Tiflis, a practically continuous line of oil seepages from both Oligocene and Miocene beds extends more than 100 miles southeastward, with a width of at least 33 miles. Oil is reported to occur on the Mugan Steppe, on both sides of the

TABLE I

CRUDE PETROLEUM PRODUCED IN EUROPEAN RUSSIA, 1821–1925*

	Baku District Metric Tons	Groznyi District Metric Tons	Kuban–Black Sea District Metric Tons	Daghestan Metric Tons	Total Metric Tons	Barrels
1821 to 1908...	161,552,120†	6,333,952†	505,173†	**	168,391,245‡	1,213,850,597
1909....	8,389,104	934,240	27,541	1,111	9,352,062‡	67,409,663
1910....	8,250,551	1,213,187	22,232	919	9,524,485‡	68,652,488
1911....	7,549,727	1,231,806	127,767	....	8,909,300	64,218,234
1912....	7,803,623	1,056,536	150,700	....	9,030,859‡	65,094,432
1913....	7,669,350	1,206,596	87,550	....	8,963,496	64,608,879
1914....	7,061,590	1,611,831	65,522	....	8,738,943	62,990,301
1915....	7,380,000	1,450,000	120,000	....	8,950,000	64,511,600
1916....	7,830,000	1,680,000	30,000	....	9,540,000	68,764,320
1917....	6,600,000	1,770,000	30,000	....	8,400,000	60,547,200
1918....	3,060,000	410,000	....	....	3,470,000	25,011,760
1919....	3,730,000	620,000	50,000	....	4,400,000	31,715,200
1920....	2,877,218	865,344	20,000	....	3,762,562	27,120,547
1921....	2,556,196	1,294,958	51,335	....	3,902,489	28,129,141
1922....	3,167,278	1,502,038	45,243	....	4,714,559	33,982,541
1923....	3,769,112	1,467,498	49,466	....	5,286,076	38,137,767
1924....	4,313,907	1,768,454	61,991	....	6,144,352	44,288,590
1925....	4,940,050	2,074,479	73,801	....	7,088,330	51,048,843
Total..	258,499,826	28,490,919	1,518,321	**	288,568,758	2,080,082,103

* *Mining Industry of Russia, 1910–12, 1914*; *Council of the Petroleum Industry*, "Handbook of the Petroleum Industry," 1915–19; *Council of the Petroleum Industry*, "Petroleum Bulletin," 1913, 1920–25.

† Estimated

‡ Includes small quantities produced in the Kutais and Elizabetpol districts.

** Included with Baku district.

Persian frontier; but this is probably in upper Tertiary strata, younger than that of the rest of the province.

In the governments of Elizabetpol and Erivan, traces of oil occur in the Miocene at Geran, 20 to 24 miles southeast of Elizabetpol, and in the Kazakh, Djevenschir, Alexandropol, and Nakhitchevan districts.

At Chatma, 36 miles east-southeast of Tiflis, a little oil was formerly obtained on a faulted anticline trending northwest-southeast and overthrust to the southwest. At Shemakha; at Khilmil, 12 miles northeast of Shemakha; between Marazin and Kurbanchi, 18 miles east-southeast of Shemakha; and at Jevat on Kura River, oil has been found in fair quantity, but development has not reached an important

stage. Other centers of operation have been at Navtluga, one mile southeast of Tiflis, and near Signakh and Tsarski-Kolodtsi.

THE KUTAIS BASIN

In Georgia, west of the Suram Mountains, which connect the Caucasus Mountains with the Armenian Plateau, extends the triangular Kutais Basin. Beneath its level surface of Quarternary alluvium it is composed of upper Tertiary beds, closely folded, and intruded in places by late Tertiary igneous rocks.

Many of the Mesozoic beds exposed on the flanks of the Caucasus contain bitumen. Within the basin, asphalt is reported from Miocene coal measures several leagues east of Gagri; and petroleum seeps from the Miocene, at Anaklia, at Supsa, and at Omparete, Maghele, Chotchkhati, Guliani, Gurianta, Chapeturi, Mikhel-Gabriel, Samkhto, Jacobi, Narudja, and Notanebi. The upper Tertiary at Kvirili, 21 miles southeast of Kutais, is stated to contain petroleum; and the Eocene rocks of Korischi, on the Khanis-takhali, 20 miles south-southeast of Kutais, show traces of oil.

Asphalt is mined at Notanebi, but no large yield of oil has been secured in any part of the field. The severe dislocations of the strata, and the high angles of dip prevailing, promote waste by natural outflow and increase the difficulties of finding intact stores of oil.

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B. RUSSIA IN ASIA

(SIBERIA AND RUSSIAN CENTRAL ASIA)

Of the geology of the vast area under Russian control, comprising nearly two-fifths of the continent of Asia, much remains to be learned. Consequently any judgment passed on its possibilities of containing oil or gas must be qualified by the phrase "so far as is known." Recent studies by Russian geologists, however, have revealed the general outlines of its geologic structure.

The geological nucleus of Russian Asia is the comparatively low-lying platform between Yenisei and Lena rivers, built of almost horizontal Cambrian and Silurian strata resting on a pre-Cambrian foundation, partly overlapped on the east by Jurassic and Cretaceous beds and covered in places by extensive outpourings of Tertiary basalt.

Around the southern margin of the central Siberian Platform, a zone of rugged mountains extends across the Siberian-Mongolian frontier, from Lake Balkhash in the southwest almost to the Sea of Okhotsk in the northeast. These are uplifted fault blocks of ancient crystalline rocks and highly folded and altered Cambrian and Ordovician beds intruded by granite of middle Paleozoic age, and of some Mesozoic rocks. Among them are many downthrown and downwarped basins, filled with little-disturbed Devonian and later Paleozoic beds. East of Lake Baikal, Devonian and later Paleozoic rocks are folded in with the mountains, and intrusions of both middle Paleozoic and late Paleozoic granite occur.

East of Lena River the central Siberian Platform is bordered by mountain ranges built of lower and middle Paleozoic and a few Triassic beds, closely folded, overturned, and overthrust, and intruded by masses of Tertiary igneous rocks. At the extreme eastern projection of Siberia the rocks are largely ancient metamorphic and igneous masses.

The mountainous peninsula of Kamchatka consists of a core of old granite, schist, and slate, and highly folded and altered Paleozoic and Mesozoic rocks, intruded by igneous rocks of different ages, and flanked on each side by a row of

Pliocene or Pleistocene volcanoes. On the west side the peninsula is bordered by folded marine and continental Pliocene beds, overlain unconformably by little-disturbed Pleistocene beds.

The Island of Sakhalin, of which the northern half belongs to Russia, is geologically a structural continuation of the Japanese Islands. North of Latitude 51° N. the folded Cretaceous rocks of the Great Sakhalin Range dip under the Tertiary, and north of Latitude 51° 30′ the Paleozoic schist of the Tym Range gives way to marine Tertiary beds; and the two ranges merge into a broad, irregular plateau built of highly folded and eroded Tertiary beds, capped in the west by almost horizontal Pleistocene.

In western Siberia, the broad low-lying, swampy plains, or tundras, lying between the Ural Mountains and Yenisei River, are underlain largely by a thin cover of slightly disturbed Lower Cretaceous and early Tertiary beds which rest unconformably upon concealed Paleozoic beds, folded chiefly on a northwest-southeast axis.

In the governments of Semipalatinsk, Akmolinsk, and Turgai, a broad uplift brings to the surface Paleozoic beds, both of marine and of continental origin, folded principally east and west, plentifully intruded by granite rocks and mineralized in many places with copper, lead, and zinc.

Russian central Asia consists of broad basins, filled with moderately folded Cretaceous and Tertiary beds largely concealed by Quaternary wind-blown sand and stream deposits, and separated by short discontinuous mountain ranges built of folded and faulted Tertiary, Cretaceous, and ancient crystalline rocks which form the structural connection between the Ural and Alai mountain systems and between the Caucasus and the mountains of central Asia. Chief of these basins are those occupied by the Transcaspian Desert (Fig. 3), Kara Kum ("Black Sand"), and Kizil Kum ("Red Sand") deserts, the Muyun Kum Desert, and the Golodnaia ("Hunger") Steppe, as well as the Ferghana Basin, which extends eastward like a tongue between the mountains of the Tien Shan and Alai systems.

Between the Caspian Sea and the Sea of Aral, the low, flat Ust-Urt Plateau is built of flat-lying Tertiary beds, which rest evidently upon an uplifted block of ancient crystalline rocks.

In the extreme west of Asiatic Russia the Emba Basin, lying between the southernmost ranges of the Ural Mountains on the east and a great fault on the west, forms a southward continuation of the East Russian Basin. Much of its low, level surface is masked by flat-lying Quaternary deposits of sandy clay and clayey sand, the underlying Permian, Mesozoic, and Tertiary beds appearing only where brought up by anticlinal folding.

Of all the mainland of Russian Asia, the most promising part for future oil supply would seem to be in the extreme southwest, in Russian central Asia, from the south end of the Ural Mountains and the east shore of the Caspian Sea to the high ranges of Turkestan. In this general region Cretaceous and early Tertiary marine strata are apparently widely distributed and have been folded in varying

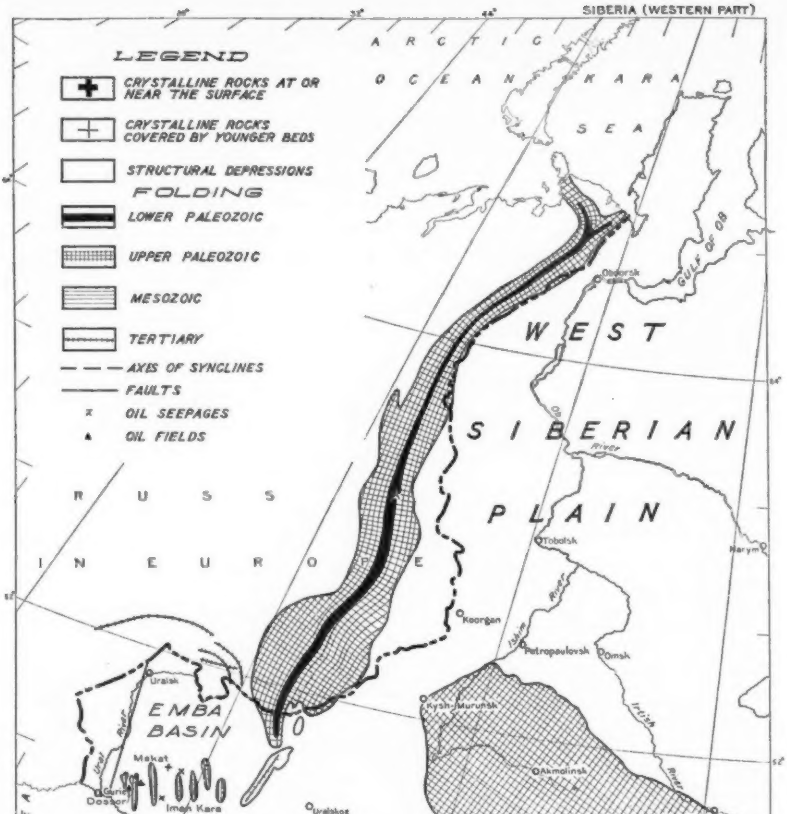

FIG. 3.—Structure Map of Western Siberia (Compiled from various sources)

degrees. Although this region has been only partly explored, and only a few localities have been tested by drilling, oil has already been produced in important quantities along the east side of the Caspian Sea, in the Province of Uralsk north of the Caspian Sea, and in the Ferghana Basin of eastern Turkestan. Some possibilities of oil or gas may exist in the broad plain of slightly disturbed Cretaceous and Tertiary beds between the Ural Mountains and Yenisei River, but these remain to be demonstrated. Surface manifestations do not occur, and the Cretaceous and Tertiary beds are thin and evidently poor in bituminous matter. In Russian Sakhalin, commercial production began in 1924.

THE EMBA BASIN

In the northern part of the Emba Basin the Mesozoic beds are folded into flat arches, trending east and west, and formed in Miocene time. In the valley of Ilek River, these folds are cross-barred with older Mesozoic dislocations, trending north and south. In the Emba River valley, truncated folds with dome-like ends prevail. These appear to form a system of dome ranges, strung like a necklace, with a prevailing north-south trend. Other trends in a transverse direction are likewise known. In places the domes are crossed by overthrusts and strike and dip faults, among which likewise a north-south trend seems to prevail. Drilling has brought to light complex structures, such as massive bodies of rock salt and gypsum, whose extent and distribution is still a subject of surmise. The intensity of the Emba folds increases to the southwest near the Ural mouths; to the southeast the folds die out as they approach the Ust-Urt Plateau.

Early drilling was largely based upon oil seepages in the lower parts of the valleys of Uil, Sagiz, and Emba rivers, derived from oil-bearing beds concealed by the Quaternary deposits. These outline an extensive oil field extending inland more than 66 miles from the shores of the Caspian, from the 46th parallel of latitude nearly to the 48th. Indications of a second oil belt are reported to occur at Port Uilsk and at some ill-defined places in the upper valley of the Emba.

Production has been obtained at Dossor, 54 miles northeast of Guriev; at Tass Kuduk, 2½ miles north of Dossor; and at Novo-Bogatinsk, 40 miles west of Guriev. Development has been confined chiefly to the Dossor field.

The oil is obtained at depths ranging from 700 to 750 feet, from oil sands low down in the Cretaceous or in the Jurassic. In view of the faulted and disturbed position of the beds in the Mesozoic, the oil may have been derived from the unconformably underlying Permian which gives indications of oil at several places in European Russia. The average daily production per well was 4,760 barrels in 1921 but only 2,663 in 1924.

The crude oil obtained at Dossor has an average specific gravity of 32.8° A.P.I. It yields on an average 20 per cent of gasoline, 42 per cent of kerosene, and 38 per cent of fuel oil. The crude oil can be used without refining directly in oil engines. At Tass Kuduk the oil has a gravity of 20.2° A.P.I. and is rich in lubricants.

Drilling began in 1909 with a few shallow wells and a small production at Dossor; at Karaton, 90 miles southeast of Dossor; at Karatchungul, 20 miles east of Karaton; and at Iskene, 18 miles southwest of Dossor. In 1911, a gusher came in at Dossor which yielded, in spite of fire and breakage of an earthen reservoir, nearly 58,333,000 barrels of oil. This centered drilling at Dossor to the neglect of the other fields. The outbreak of the World War in 1914 retarded the development of the Emba district. In 1920, however, activity was renewed.

Recently, important developments have taken place at Iman-Kara, 80 miles east of Dossor. Little is known of the results of this drilling.

THE TRANSCASPIAN BASIN

East of the Caspian Sea, between the folded Jurassic and Cretaceous beds of the low Balkhan ridge and the Kopet Dagh on the one side and the highly disturbed and intruded Paleozoic and Mesozoic strata of the North Persian Mountains on the other, lies a flat, triangular lowland, which is structurally a basin of Tertiary beds. So far as their structure can be determined beneath a broad cover of horizontal Quaternary deposits, the Tertiary beds are folded parallel to the enclosing ranges.

Oil seepages have long been known to occur on Cheleken Island, 37 miles south of Krasnovodsk, at Neftedag or Neftianaia Gora ("Oil Hill"), 20 miles south-southwest of Bala Ischem, and at Buyadag, 51 miles southeast of Neftedag.

Oil has long been obtained on Cheleken Island from a faulted dome of Tertiary beds, trending east-northeast and west-southwest. The oil occurs in Pliocene sand beds at depths ranging from 28 to 822 feet. The average daily production is 864 barrels.

At Neftedag, in a faulted dome trending generally east and west, drilling between the years 1880 and 1890 obtained a little oil at depths of 396 to 590 feet, evidently in the Pliocene.

THE FERGHANA BASIN

Around or near the margins of the Ferghana Basin, several seepages of oil issue from the folded Cretaceous and Tertiary beds: on the north side at Maili Sai, near Nanagen; east of Andidjan; and on the south side between Liakan and Chimion, south and southeast of Kokand.

Drilling has yielded oil at Chimion on a narrow dome, overthrust somewhat to the north, and at Sel Rokho or Santo, near Melnihovo on the northern limb of an anticline trending east and west.

The oil is obtained from sand beds in the Eocene clay, marl, and limestone and from sand beds in an Upper Cretaceous formation of marly clay and limestone.

The wells range in depth from 80 to 1,520 feet. The average daily yield per well is 221 barrels at Chimion and 605 barrels at Sel Rokho.

THE KARA KUM BASIN

At several places around the margin of the Kara Kum Desert indications of oil and gas occur, particularly along the southern margin between Askabad and

Serakha; between Askabad and Serakhs; between Askabad and Merv, near Pendja; and on the eastern margin near Pendjekent, 50 miles east of Samarkand.

Little has been published about these occurrences, and, so far as is known, no effort has been made to prospect or develop them. Hopes of a commercial production of oil or gas in the Kara Kum Basin may be based on its structural analogy to the Transcaspian Basin and the Ferghana Basin, both of which have produced oil.

RUSSIAN SAKHALIN

In the intensely folded, overturned, and eroded Tertiary beds of northern Sakhalin, a belt of oil seepages in Pliocene sandy beds extends 185 miles along the east coast from Okha Creek in the north to Chakre in the south, ranging from 6 to 12 miles in width, and roughly parallel to the coast. The principal seepages of petroleum and lakes and pools of paraffin occur in districts of Urkt, Nyi-Nabil, and Chaivo, along Okha, Nogligk, Nabil, Nutovo, and Boatasyn creeks. On the west coast of Russian Sakhalin, near Engis-pal, seepages of oil and deposits of "Kir" (oxidized or inspissated petroleum) are reported to occur along Langeri Brook, which flows into Amur estuary, opposite Amur River.

TABLE II

CRUDE PETROLEUM PRODUCED IN ASIATIC RUSSIA, 1900–25*

	Emba-Ural District Metric Tons	Cheleken Island Metric Tons	Ferghana District Metric Tons	Total Metric Tons	Barrels
1900 to 1908	....	44,062	206,131	250,193	1,741,343
1909	....	30,018	13,887	43,905	305,578
1910	....	129,068	28,465	157,533	1,096,430
1911	....	217,867	33,000	250,867	1,746,034
1912	18,019	212,953	33,000	263,972	1,837,245
1913	98,299	131,044	42,591	271,934	1,892,661
1914	273,562	85,181	29,486	388,149	2,701,517
1915	270,287	65,524	33,000	368,811	2,566,925
1916	253,906	49,143	33,000	336,049	2,338,901
1917	255,544	24,572	33,000	313,116	2,179,287
1918	145,791	....	24,572	170,363	1,185,726
1919	21,295	....	21,295	42,590	296,426
1920	31,123	....	18,019	49,142	342,028
1921	70,777	....	17,429	88,206	613,913
1922	136,048	....	21,167	157,215	1,094,216
1923	126,374	5,717	15,450	147,541	1,088,895
1924	139,883	....	16,622	156,505	1,066,856
1925	202,312	....	4,359	206,671	1,398,763
Total	2,043,220	995,069	624,473	3,662,762	25,492,744

* *Mining Industry of Russia*, 1910–12, 1914; *Council of the Petroleum Industry*, "Handbook of the Petroleum Industry," 1915–19; *Council of the Petroleum Industry*, "Petroleum Bulletin," 1913, 1920–25.

Such drilling as has been done on the east coast shows the presence of eight or nine productive oil sands ranging in depth from 45 feet to 930 feet below the surface. The oil sands occur in two groups, of which the upper group occurs at an average depth of 500 feet and the lower group at an average depth of 700 feet.

In the decade following the Russo-Japanese War the little-known Russian Sakhalin was prospected thoroughly, concessions were granted, and efforts to develop the concessions were made. The outbreak of the World War in 1914 put a stop to these activities.

In September, 1923, oil of high quality was produced by the Japanese, who had occupied the island since 1920, from two gushers, one on Boatasyn Creek and one in the Chaivo region. In 1924, a 600-barrel well, yielding oil of a gravity of 20° A.P.I. was struck at a depth of 400 feet. At the end of the year, producing wells had been obtained on Okha Creek; on Nutovo Creek, near Chaivo Bay; on Nogligk Creek; and on the shore of Lake Katangli, north of Nabil Bay. Statistics of the output are not yet available.

The crude oils of northeastern Sakhalin range from 18.4 to 23.8° A.P.I. and yield little gasoline. Most of the analyses of Sakhalin oil that have been published have been of oil from surface seepages, which have naturally undergone considerable alteration from their original state through evaporation and oxidation. A fresh sample of brownish-green oil, with a gravity of 24.2° A.P.I., from the sands of Nutovo River, gave on analysis 0.3 per cent of gasoline, 37.2 per cent of kerosene, and 62.5 per cent of fuel and lubricating oils.

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DISCUSSION

THE STRATIGRAPHY AND OIL PROSPECTS OF ALBERTA, CANADA

(DISCUSSION OF PAPER IN MARCH BULLETIN)

W. T. THOM, JR.: I should like to know how strongly the evidence available indicates the Triassic age of the productive limestone series at Turner Valley. Is the original correlation with the Madison limestone disproved? Such a Triassic series is without known parallel in drilled areas in northern and eastern Montana.

G. S. HUME: The Geological Survey has no exact information on the age, but sections at Banff and in other areas close by show Triassic comparable to that encountered in the Turner Valley wells.

OIL AND GAS POSSIBILITIES OF PALESTINE AND SINAI

In this *Bulletin*, Vol. 11, No. 2 (February, 1927), pp. 135–49, F. Julius Fohs presents the results of geologic research and reading by himself and W. H. Foster on the oil and gas possibilities of Palestine and Sinai. As this paper is evidently somewhat in the way of propaganda to interest those who might possibly feel inclined to spend money in Palestine to the enhancement of the interests of the Mandatory Power and of the Zionist Organization, it seems well to call attention to some further points in regard to the geology of Greater Syria and Sinai. "We are anxious to see this development undertaken because it would speed the upbuilding of Palestine as nothing else can" (p. 135) means that some industry is needed in Palestine to give employment to the hundreds of unfortunate Jews who are leading an arduous existence on remittances in that land.

The geologic column is, in the main, correct—the Danian and Campanian sections are not typical of western Sinai—at least as nearly correct as it can be in a country of rocks so lithologically similar, so sparse in fossils, and so badly faulted as in Palestine. The famous Jerusalem Anticline probably has no square mile of its surface not cut by a fault. Topographic evidences of faulting are abundant. There are two types of springs in Palestine and Syria: those in which the water is predominantly juvenile and those in which it is principally meteoric. The occurrence of the latter is such as strongly to suggest that there are deep drainage systems in the limestones, thus indicating the generally open and pervious nature of the terrains already definitely suggested by the extraordinarily prolific faulting.

Igneous activity has been very pronounced in parts of Palestine at a comparatively late date—probably Pliocene or later, certainly post-Eocene. Of the Plain of Esdraelon, for example, it is stated on page 140: "This area is occupied with several basalt intrusions." These "intrusions" are almost entirely great surface flows, many square miles in area. Although the flows are in places covered by mantle and residual deposits, their presence can be determined where they do not outcrop by the nature of the soil and by boring

as at the circular Jewish colony of Nahalal, where the basalt was encountered at a depth of 80 feet. The whole aspect of the Jerusalem Anticline is that of a highly faulted area bulged up by igneous activity and irregularly settled down with the cooling of a magma which has attained the surface here and there.

No source beds adequate to give reasonable hopes for commercial reservoirs have been found, to date, in Sinai, Palestine, or Syria. The organic material is highly asphaltic where present, and microscopic examination of rocks, from the northern end of the Dead Sea at least, shows that there has not been much change in the original organic (asphaltic, very largely) material of the possible source rocks.

"Great thicknesses of highly fossiliferous Cretaceous limestones" (p. 145), even if they occur red which they do not, are not a sufficient presumptive source for petroleum. The present writer has seen substantial beds (1 to 3 meters) of solid Cretaceous fossils in the Lebanons and in Sinai where one could not get the faintest sniff of oil. On the other hand, relatively non-fossiliferous limestones may have odors of oil on fresh fractures, and still be of no value as evidence of commercial petroleum; for example, some of the Campanian and Eocene chalk north of Abu Zenima in Sinai, or the Trenton (Platteville) limestone of southeast Missouri.

The authority of some of the early workers in Levantine geology is open to serious question, and the field man who depends much on them is likely to be led astray in Palestine. Notably, the work of M. Blanckerhorn has led to serious misconceptions of the nature of the Nile Valley, and the present writer is convinced, from observation in the field, that many of his fault patterns in Palestine are incorrect.

Good geologists of well-known American companies have "turned down" what is supposed to be the most favorable area in Palestine—the anticlines which lie to the west of the south end of the Dead Sea—for reasons which they thought entirely adequate.

For these six reasons: (1) the ulterior interest of the Mandatory Power in the oil prospecting in Palestine, (2) the general and high degree of faulting of the terrain, (3) igneous activity at and near the surface, probably more widespread than appears superficially, (4) lack of adequate source beds, (5) unreliability of results by some of the early workers, particularly by the one whose work was most extensive, and the consequent necessity for most careful areal mapping before any final conclusions may be made suitable for definite recommendations, and (6) the fact that the country has already been "turned down" by competent oil men—for these reasons taken together, even though none of them is in itself very discouraging, the present writer is led to advise definitely against exploratory drilling in Palestine, Syria, or Sinai, either now or in the near future.

D. F. Higgins

Loveland, Colorado
March 7, 1927

REVIEWS AND NEW PUBLICATIONS

Permian af Western America from the Paleobotanical Standpoint. By David White. *Proceedings of the Pan-Pacific Science Congress*, Vol. II (Australia, 1923), pp. 1,050—77.

Since the *Proceedings* of the recent Australian meeting of the Pan-Pacific Science Congress will probably have a limited distribution in America, the following brief review has been prepared to call attention to a paper which should be of special enterest to students of the American Permian.

The Permian is treated from the strictly paleobotanical standpoint, though this aspect of the subject has been too little studied to have passed beyond the exploratory stage. Under the heading, "Distribution of Permian in America," each of the provinces of Permian outcrops is reviewed, beginning with the Atlantic Province and ending with the Pacific states and Alaska. For each of these provinces the stratigraphy is outlined briefly and correlations with other American and with European Permian formations are discussed. In a concluding section of the paper, "Tectonic Movements Affecting Permian Deposition in America," the author points out the relation of the types of Permian sedimentation in the various provinces to the tectonic movements which were taking place in those and surrounding regions. This part of the paper is a very suggestive study in a field of great promise. Throughout the paper abundant references are given.

John L. Rich

Researches in Sedimentation in 1925–26. By W. H. Twenhofel, Chairman, and Members of the Committee. National Research Council, Washington, D.C., 1926. $1.00.

In a report comprising ninety-eight mimeographed pages, the authors present an outline of studies in sedimentation being pursued in the universities of North America and Europe, reviews of recent chemical and physical studies bearing on sedimentation, and special papers dealing with problems of sedimentation.

Some of the researches being carried on at the universities which will be of special interest to petroleum geologists include the compaction of sediments as related to depth of burial, being studied at Cornell University, and the porosity of sandstones and the flow of liquids through them, at the University of Pittsburgh. It was discovered at the University of Rochester that each formation of the local Silurian section may be identified by its characteristics in thin sections. The deep-sea deposits of former seas and the mode of formation of limestones in former seas have been studied in European universities. A bibliography of such studies is given.

A review of the work being done by the oil companies reveals little that is being given to the public. Heavy minerals are being found useful for correlation purposes in California, and micro-fossils in the Gulf and Mid-Continent regions.

A paper by E. M. Kindle, "Recent Studies of North American Lakes Yielding Data on Sedimentary Problems," contains much material that will be of interest to petroleum geologists in picturing the conditions under which organic and carbonaceous sediments are deposited. Several papers on modern marine sediments and sedimentary processes are reviewed by T. W. Vaughan.

Although the volume is primarily a report of progress, it contains much that will prove useful to petroleum geologists.

JOHN L. RICH

OTTAWA, KANSAS
MARCH 14, 1927

RECENT PUBLICATIONS

GENERAL

Petroleum Development and Technology in 1926, by many members of the American Institute of Mining and Metallurgical Engineers, 25 West 39th St., New York, N. Y. More than 800 pages. $6.00.

"Diamond Drilling with Special Reference to Oil-Field Prospecting and Development," by Frank A. Edson. *Bulletin 243, U. S. Bureau of Mines*, Washington, D. C. 170 pp.; 39 figs. $0.30.

"Bibliography of North American Geology for 1923–24," by John M. Nickles. *Bulletin 784, U. S. Geological Survey.* 280 pp.

"Recent Articles on Petroleum and Allied Substances," compiled by H. Britton, bibliographer. Monthly mimeographed pamphlets, *U. S. Bureau of Mines*, 506 Custom House, San Francisco, California.

CALIFORNIA

"Oil Possibilities at Comanche Point and near Wheeler Ridge, California." Memorandum for the Press No. 13,338, March 28, 1927. *U. S. Geological Survey.* 2 mimeographed pages. Refers to previous work in Bulletin 471 and Professional Paper 116.

OKLAHOMA

"Accidents in the Petroleum Industry of Oklahoma, 1915–24," by H. C. Fowler. *Tech. Paper 392, U. S. Bureau of Mines.* 29 pp.; 15 figs. $0.10.

"Water Problems in the Northern Part of the Cushing Oil Field in Creek County, Oklahoma," by D. P. Warwell, R. R. Brandenthaler, W. L. Williams, and John Van Dall. *U. S. Bureau of Mines*, Bartlesville, Oklahoma.

OKLAHOMA STATE GEOLOGICAL SURVEY

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Bulletins:

40-F, "Geology of Okmulgee County," by Robert W. Clark	$0.30
40-G, "Petroleum Geology of Oklahoma," by Sidney Powers	.30
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12. "Stratigraphic Position of the Franks and Seminole Formations of Oklahoma," by George D. Morgan .... .30
13. "Permian of Western Oklahoma and the Panhandle of Texas," by Charles N. Gould and Frank E. Lewis .... .30
14. "The Arbuckle Mountains," by Chester A. Reeds .... .10

GERMANY

Geologie der Umgegend von Bonn (*Geology near Bonn*), by Otto Wilchens. Gebrüder Borntraeger, W. 35 Schöneberger Ufer 12 a, Berlin. Title page, 10 tables, 44 illustrations, 273 pages. Bound, M. 19.50.

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H. J. Hawley, S. H. Gester, Fred A. Davies

Victor Seymour Davenport, Los Angeles, Calif.
E. M. Butterworth, William S. W. Kew, Herschel L. Driver

Herman Albert Fonville, Laredo, Tex.
Djevad Eyoub, F. L. Whitney, Fred M. Bullard

Ralph E. Grim, University, Miss.
E. N. Lowe, Alan Bateman, Edwin Binney, Jr.

George A. Grimm, Norman, Okla.
Charles E. Decker, V. E. Monnett, A. L. Beekly

Edward Franklin Hagan, Tulsa, Okla.
R. M. Gawthrop, Ray V. Hennen, Thos. W. Leach

Raymond Holden Haseltine, Dallas, Tex.
Douglas M. Collingwood, Leon J. Pepperberg, Samuel H. Williston

Joe C. Hemphill, Wichita Falls, Tex.
J. V. Howell, C. E. Hyde, Paul B. Hunter

William Harry Holman, Los Angeles, Calif.
E. M. Butterworth, O. A. Cavins, Herschel L. Driver

C. J. Knutson, Ponca City, Okla.
Stuart K. Clark, Glenn C. Clark, E. L. Jones, Jr.

Mirabeau B. Lamar, Eastland, Tex.
H. B. Fuqua, David Donoghue, Ben C. Belt

Frank Parkes Latimer, Idabel, Okla.
Charles E. Decker, V. E. Monnett, R. J. Riggs

Gage Virtus Lund, Billings, Mont.
H. J. Hawley, S. H. Gester, Fred A. Davies

Robert L. McLaren, Cisco, Tex.
Ed. W. Owen, E. L. Porch, Jr., T. M. Prettyman

Selden Spencer Nye, Brownsville, Tex.
W. B. Lang, W. T. Thom, Jr., C. E. Dobbin
Walter Sigfrid Olson, Eastland, Tex.
H. B. Fuqua, David Donoghue, Ben C. Belt
Claude P. Parsons, Cyril, Okla.
Clifton R. Swarts, E. P. Campbell, R. R. Brandenthaler
Herman W. Pontius, Fort Worth, Tex.
Frank E. Lewis, R. J. Metcalf, Ray V. Hennen
William Woods Porter, Tampico, Mexico
W. F. Eastman, Kirtley F. Mather, Shirley L. Mason
John Stowe Redfield, Norman, Okla.
Charles N. Gould, V. E. Monnett, Charles E. Decker
Elmer M. Rice, Mexia, Tex.
R. A. Liddle, Theron Wasson, J. Earle Brown
Harris Nelson Seevers, Wichita Falls, Tex.
R. B. Whitehead, Wallace C. Thompson, I. R. Sheldon
Gerhard G. Senftleben, Tulsa, Okla.
Ed. Bloesch, James B. Templeton, Roy A. Reynolds
George James Smith, Los Angeles, Calif.
M. G. Edwards, Roy R. Morse, E. F. Davis
Charles Alfred Stewart, San Antonio, Tex.
George D. Morgan, Herschel H. Cooper, D. C. Barnett
Jefferson A. Stone, Norman, Okla.
Charles E. Decker, Charles N. Gould, V. E. Monnett
Hugh Alexander Tanner, Thurber, Tex.
O. F. Hedrick, C. E. Yager, David Donoghue
Raymond H. Thompson, Shreveport, La.
S. P. Borden, S. E. Mix, W. C. Spooner
James Dale Thomson, Oklahoma City, Okla.
Charles E. Decker, G. E. Anderson, V. E. Monnett
Vergil E. Tims, Wichita Falls, Tex.
G. E. Laskey, W. C. Bean, Urban B. Hughes

FOR TRANSFER TO ACTIVE MEMBERSHIP

Ronald James Cullen, Tulsa, Okla
Sidney Powers, Dollie Radler, L. B. Snider
James Ira Daniels, Ponca City, Okla.
Stuart K. Clark, Glenn C. Clark, Joseph A. Cushman
William Fred Earl, Tulsa, Okla.
Ray V. Hennen, Thomas W. Leach, C. A. Yoakam
Chester M. Gardiner, Los Angeles, Calif.
T. E. Swigart, C. M. Wagner, Irvine E. Stewart
George M. Knebel, Jr., Mart, Tex.
E. Holman, Wallace E. Pratt, John R. Suman
William S. Levings, Denver, Colo.
P. E. Nolan, Samuel W. Riter, C. M. Crebbs

Benedict Edward Thompson, Fort Worth, Tex.
H. B. Fuqua, David Donoghue, C. E. Yager
Joseph Dent Watson, Tulsa, Okla.
Luther H. White, Charles T. Kirk, Glenn C. Clark
Paul Atwood Whitney, Tulsa, Okla.
H. W. Peabody, A. L. Beekly, F. W. Bartlett

DISCUSSIONS

It is highly desirable that members submit discussions of papers presented at Association meetings or published in the *Bulletin*. Information on the many phases of petroleum geology and technology is generally subject to revision with new developments and the gathering of additional facts. The members who devote time and energy to the accumulation and classification of useful data should be accorded at least due recognition of their contribution to the particular problem under consideration. Their papers may be made much more valuable and usable if another member submits extra facts, offers further argument, or points out mistakes and suggests corrections. A paper cannot be thoroughly useful unless it evokes discussion; and to be of utmost benefit to the Association, both the original paper and the discussions of it should be submitted for publication in the *Bulletin*.

TWELFTH ANNUAL MEETING OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS, TULSA, OKLAHOMA, MARCH 24, 25, AND 26, 1927

ALEX W. McCOY, *PRESIDING*

Each succeeding annual meeting of the Association in recent years has so far surpassed in popularity each previous gathering that new historians may soon be needed with new vocabularies to record the main events if we are to escape the habit of using that long familiar superlative, "the biggest ever." A one-man description of this convention is utterly inadequate. A merely normal set of faculties could not fully comprehend all the activities.

Eighteen hundred twenty-seven registrations! Such figures suggest the thought that an every-member canvass of petroleum geologists might have been completed at this convention, and the thought is especially impressive to one who stood on the Mayo mezzanine vainly flagging sixteen, and more, full express elevators headed for the sixteenth-floor technical sessions, or to one helplessly swaying in the good-natured human traffic jam that rushed the doors of the Akdar theater. Yet the members attending the meeting numbered only 769. The registration figure of 1827 may indicate the success of petroleum geology, or the popularity of A.A.P.G. conventions.

Arrangements for the whole meeting appear to have been carried out quite satisfactorily. The record crowd was registered, banqueted, and entertained with relatively little confusion.

One whole parlor on the mezzanine was devoted to registration in all its classifications for member and non-member attendance, hotel reservations, payment of dues, purchase

of banquet tickets, securing show and dance tickets, reservations for field trips, participation in golf tournaments, and balloting for officers. Registration certificates or identification tickets assured to those properly entitled the privileges of the convention. Only thus could the unusual number of members and their ever increasing number of guests have been certain of a place at the social events whose popularity with non-member friends grows greater year by year.

The program overflowed the allotted three-day sessions, both before and after. On Wednesday the paleontologists and microscopists conducted a preconvention laboratory period with microscopes and slides, and preliminary meetings were held by the Executive, Research, Business, and other committees. The Executive Committee elected Dr. J. A. Udden and Dr. Charles E. Decker to honorary membership.

All sessions of the Association, except Friday afternoon, were held on the sixteenth floor of the Mayo Hotel, the main sessions in the Crystal ballroom and the sections in the banquet hall. Large bulletin boards in rooms near the Crystal ballroom were used to display maps accompanying papers not orally delivered at the meeting. Commercial exhibits of maps and field and laboratory equipment were also arranged on the sixteenth floor. On Friday afternoon the business session convened in the auditorium of the Tulsa High School, and the afternoon's technical papers were delivered there, so that the Crystal ballroom could be made ready for the banquet. An organ recital was enjoyed between the business and technical sessions.

The officers elected for the year 1927–28 are: G. C. Gester, of San Francisco, president (unanimous); Luther H. White, of Tulsa, vice-president; David Donoghue, of Fort Worth, secretary-treasurer; and John L. Rich, Ottawa, Kansas, editor (re-elected).

Three separate banquets, held simultaneously this year, accommodated the crowd that could not have been properly cared for all in one place. Missouri Valley college groups assembled in the Mayo Hotel, the Big Ten and eastern colleges in the Tulsa Hotel, and southwestern and western groups in the Masonic Temple. College colors on many toy balloons, college yells, songs, and impromptu speeches marked the successful handling of the banquet by this new method of athletic conference grouping.

The banqueters were transported by automobile to the beautiful Akdar theater where the Tulsa Geological Society admirably presented "The Rockhound Revue," with a galaxy of all-Tulsa talent readily recognized by an appreciative audience as being charmingly unconfined to geological or masculine lines. After a delightfully varied entertainment ranging from black-face wit to Little Theater worth, the dance of the evening (and following morning) closed the biggest day of the biggest convention.

The paleontologists and associated members, who held their first separate sessions last year at Dallas, organized as the Society of Economic Paleontologists and Mineralogists, with the following officers for 1927–28: J. J. Galloway, of New York, president; C. Don Hughes, of Amarillo, Texas, vice-president; Marcus A. Hanna, of Houston, secretary-treasurer; and Joseph A. Cushman, of Sharon, Massachusetts, editor. The Society will publish a quarterly journal.

About eighty-five members and guests participated in the golf tournament Friday afternoon. Handicap medal play was the basis of competition, with the players grouped in four flights arranged according to handicap. Fred Daniel, of Tulsa, won the Bostick Cup, a trophy presented each year by J. Wallace Bostick, of Dallas, to bring out the utmost endeavor of the golfing enthusiasts among the convention's guests. In the members' tournament, a large silver tray was awarded to the winner of the championship flight, and

a silver pitcher to the runner-up. In flights A, B, and C, each winner was awarded a handsome golf bag and each runner-up a Spaulding steel-shaft driver.

The winners were as follows:

	Handicap	Net Score
Championship		
Hastings Moore, Tulsa	12	73
H. N. Seevers, Wichita Falls	14	75
Class A		
G. C. Potter, Tulsa	16	71
C. H. Eaton, Enid	17	76
Class B		
W. A. Reiter, Mexia	22	72
H. M. Robinson, Dallas	22	76
Class C		
Don Danvers, Corsicana	26	67
F. C. Sealey, Wichita Falls	24	68

Ladies' special entertainment included a tea at Oakhurst Country Club, an auto ride around the city, and a matinée at the Ritz theater.

Post-convention field trips to Seminole, to the oil fields near Ponca City, to Ardmore for type exposures in the Arbuckle Mountains, and to other Oklahoma fields proved to be popular. The novel features of the Ponca City trip were the 101 Ranch wild-west show and buffalo barbecue given by the Miller Brothers.

The Tulsa convention, unprecedented in size and unsurpassed in pleasing management, was the result of the enthusiastic work of the committees of the Tulsa Geological Society.

TULSA GEOLOGICAL SOCIETY COMMITTEE OF ARRANGEMENTS

General Committee.—M. M. Valerius, *Chairman;* A. L. Beekly, A. W. Duston, J. H. Gardner, F. C. Greene, Frank A. Herald, Richard Hughes, Harry H. Nowlan, G. C. Potter, Sidney Powers, T. E. Weirich, L. G. Welsh, L. H. White, V. H. Hughes.

Banquets.—Richard Hughes, *Chairman;* W. J. Allen, W. E. Bernard, G. S. Buchanan, Harry J. Brown, R. H. Dott, H. B. Goodrich, W. R. Hamilton, B. H. Harlton, E. D. Luman, O. G. McDonald, John W. Merritt, Burr McWhirt, R. A. Moore, H. G. Officer, C. L. Severy, R. S. Tarr.

Decorations.—V. H. Hughes, *Chairman;* C. A. Cheney, George E. Dorsey, E. N. Murphy, L. J. Zoller.

Entertainment.—Harry H. Nowlan, *Chairman;* Bernard H. Lasky, Chas. H. Pishney, E. F. Shea, C. C. Toomey, A. F. Truex, Herb. E. Williams.

Exhibits.—F. C. Greene, *Chairman;* Ed. Bloesch, Ira H. Cram, L. L. Hutchison, E. D. Luman, H. W. Peabody.

Finance.—J. H. Gardner, *Chairman;* Fritz L. Aurin, S. J. Caudill, David Logan, R. S. McFarland, S. S. Price, R. J. Riggs, W. B. Wilson, R. H. Wood.

Golf Tournament.—A. L. Beekly, *Chairman;* W. R. Hamilton, T. K. Harnsberger, H. M. Scott.

Hotels.—G. C. Potter, *Chairman;* G. S. Dunlap, Wesley G. Gish, W. B. Henderson, Thos. W. Leach, W. R. Longmire, O. G. McDonald, L. Murray Neumann, C. R. Thomas, Virgil H. Wood.

Ladies' Entertainment.—T. E. Weirich, *Chairman;* Mrs. Harry J. Brown, Miss Constance G. Eirich, Mrs. A. A. Langworthy, Mrs. E. W. McCrary, Miss Dollie Radler.

Program.—Sidney Powers, *Chairman;* E. DeGolyer, G. C. Gester, Frank C. Greene, F. G. Holl, T. S. Harrison, K. C. Heald, F. H. Lahee, Henry A. Ley, W. E. Pratt, C. W. Tomlinson, Luther H. White.

Publicity.—Luther H. White, *Chairman;* Carl B. Anderson, Geo. S. Buchanan, R. J. Davis, Richard Hughes, E. G. Woodruff, Harry F. Wright.

Reception.—L. G. Welsh, *Chairman;* Russell Bickel, L. L. Foley, Geo. A. Kroenlein, A. I. Levorsen, J. N. McGirl, C. M. Sale, W. J. Sherry, C. D. Stephenson.

Registration.—Frank A. Herald, *Chairman;* Frank R. Clark, J. P. D. Hull, W. W. Keeler, A. A. Langworthy, A. W. Lauer, J. O. Lewis, E. W. McCrary, V. H. McNutt, Burr McWhirt, M. J. Munn, H. E. Rothrock, Paul Ruedemann.

Transportation.—A. W. Duston, *Chairman;* W. L. Foster, H. B. Goodrich, L. E. Kennedy, Chas. T. Kirk, D. H. Radcliffe, Geo. S. Rollin, J. C. Ross, C. L. Severy, R. J. St. Germain, Al Winn.

PROGRAM

INTRODUCTORY REMARKS

M. M. Valerius, general chairman, local committee on arrangements

ADDRESSES OF WELCOME

A. L. Beekly, president, Tulsa Geological Society

Harry Halley, city attorney, representing Mayor Newblock of Tulsa

RESPONSE

Alex W. McCoy, president, American Association of Petroleum Geologists

REPORTS OF OFFICERS

Alex W. McCoy, president

Fritz L. Aurin, secretary-treasurer

John L. Rich, editor

PAPERS

NEW DEVELOPMENTS

1. New Developments in California and Their Significance—C. H. BEAL and A. H. HELLER
2. New Developments in West Texas—ROBERT BURNS CAMPBELL
3. New Developments on the Gulf Coast—ALEXANDER DEUSSEN
4. New Developments at Amarillo—C. MAX BAUER
5. New Developments in the Seminole District—T. E. Weirich

SYMPOSIUM ON THE RELATION OF STRUCTURE TO PETROLEUM ACCUMULATION IN OIL FIELDS

6. California—G. C. GESTER and E. C. GAYLORD
7. Elk Hills, California—P. V. ROUNDY
8. Blackwell and South Ponca, Oklahoma—S. K. CLARK and J. I. DANIELS
9. Lost Soldier, Wyoming—J. S. IRWIN
10. Copley Oil Pool, West Virginia—D. B. REGER
11. Publicity—RALPH ARNOLD
12. Pine Island, Louisiana—A. F. CRIDER
13. Peabody-Elbing-Urschel-Covert-Sellers, Kansas—C. R. THOMAS
14. Fort Collins, Colorado—W. G. GALLAGHER and S. GRINSFELDER

15. Paint Creek Uplift, Kentucky—I. B. BROWNING
16. Cabin Creek, West Virginia—THERON WASSON
17. Bellevue, Louisiana—L. P. TEAS
18. Illinois—G. F. MOULTON and A. H. BELL
19. Bradford, Pennsylvania—J. R. NEWBY, P. D. TORREY, C. R. FETTKE, and L. S. PANYITY
20. Griffithsville and Tanner Creek, West Virginia—E. A. STEPHENSON and R. E. DAVIS
21. Garber, Oklahoma—W. G. GISH and R. M. CARR
22. Glenn Pool, Oklahoma—W. B. WILSON
23. Mexia-Wortham-Currie-Powell, Texas—F. H. LAHEE
24. Homer, Louisiana—W. C. SPOONER
25. Desdemona, Texas—DAVID DONOGHUE
26. Ordovician Correlations in Oklahoma—FANNY C. EDSON
27. Cushing, Oklahoma—J. N. McGIRL, A. F. TRUEX, A. L. BEEKLY, and R. R. BRANDENTHALER
28. Russell, Kansas—T. H. ALLEN and M. M. VALERIUS
29. Luling, Texas (Geology and Petroleum Resources of the San Marcos Quadrangle)—E. W. BRUCKS
30. South Vernon, Texas—H. B. FUQUA
31. The Turkey Mountain Lime, Oklahoma—PAUL RUEDEMANN and H. E. REDMON

GENERAL

32. Criteria for Oil Occurrence—F. G. CLAPP
33. Origin of Oil in California—C. F. TOLMAN
34. Stratigraphic Position of the "Big Lime" in West Texas—E. C. EDWARDS
35. Convergence Studies in the Mid-Continent Region—A. I. LEVORSEN
36. Boulders of Ordovician Age in the Caney Shale of the Ouachita Mountains—E. O. ULRICH
37. The Oil Well Decline Formula—R. H. JOHNSON
38. Generation of Oil by Geological Distillation—J. L. RICH
39. Oil Possibilities in the Arkansas Valley Region, Arkansas—G. C. BRANNER
40. Calcium Chloride Waters, Connate and Diagenetic—ALFRED C. LANE
41. New Appraisal Methods—S. J. CAUDILL
42. Possibility of a Southwestern Extension of the Cincinnati Arch under the Gulf Embayment—WILBUR C. NELSON
43. Origin and Significance of Epi-anticlinal Faults as Revealed by Experimental Study—T. A. LINK
44. History of Carboniferous Sediments of the Mid-Continent Region—M. G. CHENEY
45. Recent Petroleum Activities on the Olympic Peninsula; Summary of Geology—R. H. PALMER
46. The Effectiveness of Compaction as a Cause of Migration of Petroleum—R. C. BECKSTROM and F. M. VAN TUYL
47. Some Problems of the Chugwater-Sundance Contact in the Big Horn District of Wyoming—A. E. BRAINERD and I. A. KEYTE
48. Distribution and Correlation of the Mississippian of Oklahoma—G. S. BUCHANAN
49. Petrographic Study of the Pre-Cambrian of Kansas—K. K. LANDES

50. Igneous Dikes in Bandera County, Texas—GRADY KIRBY, J. M. DAWSON, and M. A. HANNA
51. Western "Redbeds," Marine or Non-marine?—E. B. BRANSON
52. Kerogen and Its Relation to Petroleum—G. L. SHUE and G. W. THOMAS
53. Some Questions on the Subsidence of the Surface of Goose Creek Field, Texas—L. C. SNIDER
54. Big Sand Draw, Fremont County, Wyoming—COLIN C. RAE.
55. Gaptank-Wolfcamp Problem of the Glass Mountains, Texas—I. A. KEYTE, W. GRANT BLANCHARD, JR., and H. L. BALDWIN, JR.

PALEONTOLOGY

1. Lowest Known Tertiary Diatoms in California—G. D. HANNA
2. The Use of Evolutionary Changes in Geologic Correlation—N. L. THOMAS
3. Changing Characters in Some Texas Species of Guembelina—N. L. THOMAS and E. M. RICE
4. The Nomenclature of Some Common Genera of Foraminifera—J. J. GALLOWAY
5. Pleistocene Foraminifera from the Lomita Quarry, Palos Verdes Hills, California—J. J. GALLOWAY and S. G. WISSLER
6. A Lower Pico Foraminiferal Fauna from Southern California—G. H. DOANE and S. G. WISSLER
7. Additional Pennsylvanian Foraminifera of the Glenn Formation of Southern Oklahoma—B. H. HARLTON
8. The Value of Micropaleontology—E. O. ULRICH
9. New Faunal Evidence from the Tensleep Formation, Wyoming—A. E. BRAINERD and I. A. KEYTE
10. Sedimentary Petrography in the Gulf Coast Region—MARCUS A. HANNA
11. Small Fossils from the Midway Formation of Texas, Other than Foraminifera—F. B. PLUMMER
12. Some General Hints on the Study of Foraminifera for Descriptive and Correlation Purposes—J. A. CUSHMAN
13. The Use of Evolutionary Changes in Geologic Correlation—N. L. THOMAS
14. Microfossils in the West Texas Geologic Section—HEDWIG T. KNIKER
15. Microscopic Identification of Formations at Amarillo—JOSEPH MAUCINI

PALEONTOLOGICAL PAPERS LISTED BY TITLE

Stratigraphic Range and Importance of *Bairdia subdeltoides* Munster, C. I. ALEXANDER; Pennsylvanian and Mississippian Foraminifera of the Mid-Continent Oil Fields, B. H. HARLTON; Some Pennsylvanian Ostracoda of the Glenn Formation of Southern Oklahoma, B. H. HARLTON; Pennsylvanian Ostracoda of the Genus *Healdia*, F. A. BUSH.

SYMPOSIUM PAPERS BY TITLE

Appalachian Region.—Appalachian Region, G. B. RICHARDSON; Cross-sections of the Appalachian Oil Field Region, J. FRENCH ROBINSON.

Arkansas.—Smackover, H. G. SCHNEIDER; Irma, L. P. TEAS; Lisbon, N. B. WINTER; Stephens, L. S. HARLOWE.

California.—Dominguez, A. C. RUBEL; Coalinga, E. F. DAVIS and A. M. HAZZARD; McKittrick, W. A. ENGLISH; Sedimentation of the Pico Formation in the Ventura Quadrangle, LON D. CARTWRIGHT, JR.

Colorado.—Moffat, H. A. Stewart; Florence, R. K. DeFord; Boulder, Paul Whitney.

Indiana.—Southwestern Indiana, R. E. Esarey.

Kansas.—22-10, R. E. Bending; Winfield, Everett Carpenter; Longton, H. A. Ley; Virgil, A. L. Beekly; Webb-Coleman, C. W. Studt; South Coffeyville, W. H. Foster; Rainbow Bend, R. B. Rutledge and D. R. Snow; Fox Bush, R. B. Rutledge and D. R. Snow; Greenwood County, W. K. Cadman.

Kentucky.—Relation of Structure to Petroleum Accumulation in Five Oil and Gas Fields in the Eastern Coal Fields of Kentucky, L. E. Fiske; Wayne County, E. A. Stephenson.

Louisiana.—Caddo, H. K. Shearer, S. C. Stathers, and J. S. Ivy; Urania, George Schneider and Sidney Packard; Haynesville, C. L. Moody; Cotton Valley, L. S. Harlowe.

Michigan.—Michigan, G. C. Carlson.

Montana.—Geology of the Sweet Grass Arch, Ralph Arnold and E. B. Emrich; Cat Creek, C. T. Lupton; Kevin-Sunburst, W. F. Howell and V. Hendrickson.

New Mexico.—Artesia, M. J. Davis; Hogback, R. C. Coffin; Rattlesnake, H. J. Packard.

New York.—New York, C. A. Hartnagel.

Ohio.—Eastern Ohio, J. R. Lockett; Berea Sand Production, T. C. Hiestand; Geologic Structure in Portions of Eastern Ohio, K. C. Cottingham.

Oklahoma.—Cromwell Field, L. G. Keppler, A. W. Lauer, and George Kroenlein; Wilcox Fields, near Hominy, W. D. Gray; Mounds, J. L. Gartner; Ingalls-Ripley-Mehan, W. C. Adams and W. J. Allen; Delaware Pool, J. O. Lewis; Stroud, L. H. White; Davenport, Dollie Radler; Burbank, J. M. Sands; 22-16-12 and 7-15-13, A. W. Duston; Depew, L. M. Neumann; Cleveland, Robert H. Wood and W. W. Keeler; Terlton, Virgil O. Wood; Pawhuska, C. D. Stephenson; Wewoka, E. F. Shea and L. G. Mosberg; 23-16-8, J. W. Merritt; Watchorn, Everett Carpenter; Dallas-Osage, D. P. Coleman; Hewitt, G. E. Burton; North Duncan, Frank Gouin; Graham, C. W. Tomlinson; Crinerville, Sidney Powers.

Pennsylvania.—McKeesport, J. French Robinson.

Tennessee.—Tennessee, R. G. Lusk.

Texas.—Petrolia, F. E. Kendrick and H. C. McLaughlin; Woodson Oil Field, Throckmorton County, W. H. Foster; Carolina-Texas Gas Field, Webb County, Paul W. McFarland; The Oligocene of Texas, Alva C. Ellisor; Ivan, L. J. Pepperberg; Nigger Creek, L. J. Pepperberg; Ibex, Ford Bradish; Nocona, F. W. DeWolf; Stephens County, J. Elmer Thomas and M. B. Livingston; Big Lake, R. V. Hennen; Ragel-Carey-Harmel-Swastika, W. C. Thompson and W. E. Hubbard; Henderson-Holden Gas Field, Grady Kirby and J. M. Dawson.

Utah.—Structural History of Parts of Southeastern Utah Based on Interpretation of Geologic Sections, H. W. C. Prommel and H. E. Crum; Notes on the Stratigraphy of the Moab Region, A. A. Baker, C. E. Dobbin, E. J. McKnight, and J. B. Reeside, Jr.

Wyoming.—Salt Creek and Teapot Dome, J. G. Bartram and Fred E. Wood; Lance Creek, W. B. Emery; Grass Creek, T. S. Harrison; Rock River, W. B. Emery and C. J. Hares; Elk Basin, J. G. Bartram.

Foreign.—Bituminous Sands of Northern Alberta, S. C. Ells; Geology of the Oil Fields of Burma, L. Dudley Stamp; Oil and Gas Prospects on the East Coast of North Island, New Zealand, F. G. Clapp; Oil Fields and Oil Prospects of Italy, Frank E. Lewis.

The registration committee recorded the following registrations at the Tulsa meeting: (1) honorary members, 2, (2) active members, 538, (3) associate members, 229, (4) visiting ladies, 236, (5) Tulsa ladies, 216, (6) men guests, 268, and (7) non-members, 338, making a grand total of 1,827 registrations. The list of members attending is as follows:

MEMBERS ATTENDING TWELFTH ANNUAL MEETING

HONORARY

White, David, Washington, D.C.
White, I. C., Morgantown, W.Va.

ACTIVE

Absher, Wm. F., Bartlesville, Okla.
Adams, William C. Tulsa, Okla.
Ainsworth, Wm. L., Wichita, Kan.
Allen, Walter J., Tulsa, Okla.
Ambrose, A. W., Bartlesville, Okla.
Ames, Edward W., Cisco, Tex.
Ames, Elmer R., Los Angeles, Calif.
Anderson, Amil A., Wichita, Kan.
Anderson, Carl B., Tulsa, Okla.
Andrews, Sylvan H., Okmulgee, Okla.
Armstrong, J. M. Eastland, Tex.
Arnett, Clarence L., Ponca City, Okla.
Arnold, Ralph, Los Angeles, Calif.
Athy, Lawrence F., Ponca City, Okla.
Aurin, Fritz L., Ponca City, Okla.
Baker, Raymond F., Houston, Tex.
Baldwin, Harry L., Jr., Denver, Colo.
Ball, Max W., Denver, Colo.
Barrett, William G., Farmington, Mo.
Barrow, Leonidas T., San Antonio, Tex.
Bartlett, Fred W., Amarillo, Tex.
Barton, Donald C., Houston, Tex.
Bartram, John G., Denver, Colo.
Bauer, C. Max, Amarillo, Tex.
Bean, Ward C., Shreveport, La.
Beckelhymer, Roy L., Camden, Ark.
Becker, Clyde M., Chickasha, Okla.
Beckwith, Henry T., Tulsa, Okla.
Beecher, Charles E., Bartlesville, Okla.
Beede, J. W., San Angelo, Tex.
Beekly, Albert L., Tulsa, Okla.
Belt, Ben C., Forth Worth, Tex.
Bending, Ralph E., Kansas City, Mo.
Benton, Louis B., Cisco, Tex.
Berger, Walter R., Forth Worth, Tex.
Bernard, W. E., Tulsa, Okla.
Best, J. Boyd, Laredo, Tex.
Binney, Edwin, Jr., New Haven, Conn.
Birk, Ralph A., Ardmore, Okla.
Blanchard, W. Grant, Jr., Denver, Colo.
Bloesch, Edward, Tulsa, Okla.
Borden, S. P., Shreveport, La.
Bostick, J. Wallace, Dallas, Tex.
Bowen, James P., Wichita Falls, Tex.
Bowman, Wayne F., Houston, Tex.
Boyd, Harold, New York, N.Y.
Boyle, Albert C., Jr., Laramie, Wyo.
Brace, Orval L., Shreveport, La.
Bradish, Ford, Fort Worth, Tex.
Brainerd, Arthur E., Denver, Colo.
Brainerd, William F., Wichita Falls, Tex.
Brandenthaler, Rudolph R., Bartlesville, Okla.
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Brauchli, Rud., Oklahoma City, Okla.
Briscoe, Glenn O., San Angelo, Tex.
Brown, Harry J., Tulsa, Okla.
Brown, J. Earle, Fort Worth, Tex.
Browning, Iley B., Ashland, Ky.
Brucks, Ernest W., Laredo, Tex.
Bruyere, Alan, Fort Worth, Tex.
Bullard, Edgar F., Wichita Falls, Tex.
Bunn, John R., Ardmore, Okla.
Burg, Robert S., Fort Worth, Tex.
Burress, Walter M., Alexander Bldg., Abilene, Tex.
Burt, Roy A., Kansas City, Mo.
Burton, George E., Ardmore, Okla.
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Bybee, H. P., San Angelo, Tex.
Cadman, Wilson Kennedy, Wichita, Kan.
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Campbell, Robert B., San Angelo, Tex.
Cannon, Robert L., Dallas, Tex.
Carlson, Charles G., Tulsa, Okla.
Carlton, Dave P., Houston, Tex.
Carpenter, Everett, Bartlesville, Okla.
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Caudill, Samuel J., Tulsa, Okla.

Cave, Harold S., Roswell, N.Mex.
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Cheney, M. G., Coleman, Tex.
Chevalier, Jerome A., Tulsa, Okla.
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Clark, Chester C., Shreveport, La.
Clark, Clifton W., Wichita Falls, Tex.
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Clark, Glenn C., Ponca City, Okla.
Clark, Howard, Coleman, Tex.
Clark, Robert W., Okmulgee, Okla.
Clark, Stuart K., Ponca City, Okla.
Clarke, Carl W., Tulsa, Okla.
Clifton, R. L., Enid, Okla.
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Dannenberg, Richard M., Marland, Okla.
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Davis, Thornton, Wichita Falls, Tex.
Dawson, Joseph M., San Antonio, Tex.
Day, Willard L., Amarillo, Tex.
Dean, Paul, Tulsa, Okla.
Decker, Charles E., Norman, Okla.
De Coussér, Kurt H., Tulsa, Okla.
Denison, A. R., Tulsa, Okla.
De Wolf, Frank W., Houston, Tex.
Dobbin, Carroll E., Washington, D.C.
Dodson, Floyd C., San Angelo, Tex.
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Dorsey, Geo. Edwin, Dallas, Tex.
Dott, Robert H., Tulsa, Okla.
Doub, Charles O., Graham, Tex.
Duce, James T., New York City
Dunlevy, Robert B., Winfield, Kan.
Duston, Arthur W., Tulsa, Okla.
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Ebmeyer, Gerard E., Amarillo, Tex.
Eby, J. Brian, Houston, Tex.
Eckes, Charles R., Tulsa, Okla.
Edson, Fanny Carter, Tulsa, Okla.
Edwards, Everett C., San Angelo, Tex.
Egan, John A., Abilene, Tex.
Eirich, Constance G., Tulsa, Okla.
Elledge, George A., Houston, Tex.
Elliott, John E., Los Angeles, Calif.
Ellisor, Alva C., Houston, Tex.
English, Leon E., Lawton, Okla.
Evans, Noel, Ponca City, Okla.
Eyssell, Alfred R., San Angelo, Tex.
Fath, A. E. Chrisman, Ill.
Ferguson, John L., Amarillo, Tex.
Finch, Elmer H., Shreveport, La.
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Fohs, F. Julius, New York, N.Y.
Foley, Lyndon L., Tulsa, Okla.
Folger, Anthony, Wichita, Kan.
Ford, Carl S., Enid, Okla.
Forrester, George A., Wichita, Kan.
Foster, F. K., Wichita Falls, Tex.
Foster, Walter Lee, Tulsa, Okla.
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Fowler, George M., Joplin, Mo.
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Garrett, Melvin M., Wichita Falls, Tex.
Garrett, Robert E., Tulsa, Okla.
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Harrison, Thomas S., Denver, Colo.
Hartley, Burton, Cisco, Tex.
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Jones, James J., Tulsa, Okla.
Justice, Philip S., Beaumont, Tex.
Keeler, William W., Tulsa, Okla.
Keller, P. Hastings, Ardmore, Okla.
Kellum, Lewis B., Tampico, Mexico.
Kendrick, Frank E., Dallas, Tex.
Kennedy, Luther E., Tulsa, Okla.
Kent, Joseph T., Dallas, Tex.
Keppler, Leo G., Tulsa, Okla.
Kernan, Thomas H., St. Louis, Mo.
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Lahee, Frederic H., Dallas, Tex.
Laird, B. L., Colorado, Tex.
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Langworthy, A. A., Tulsa, Okla.
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Loomis, Harve, Baird, Tex.
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Lucky, Maurice C., San Angelo, Tex.
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Lyons, Richard T., San Angelo, Tex.
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MacKay, Hugh, Sapulpa, Okla.
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Martin, George C., Washington, D.C.
Martin, Helen M., Tulsa, Okla.
Mason, Shirley L., Pittsburgh, Pa.
Masterson, Rebecca, Houston, Tex.
Matson, George C., Tulsa, Okla.
McCluer, R. D., Corsicana, Tex.
McCollom, C. R., Los Angeles, Calif.
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McCrary, E. W., Tulsa, Okla.
McFarland, R. S., Tulsa, Okla.
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Merritt, J. W., Tulsa, Okla.
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Millikan, C. V., Tulsa, Okla.
Mills, R. Van A., Bartlesville, Okla.
Miser, Hugh D., Washington, D.C.
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Moncrief, E. C., Wichita, Kan.
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Moore, John I., San Angelo, Tex.
Moore, Raymond C., Lawrence, Kan.
Morgan, D. M., Ponca City, Okla.
Morgan, George D., San Antonio, Tex.
Morley, Harold T., Abilene, Tex.
Morris, A. F., Bartlesville, Okla.
Morse, Roy R., Los Angeles, Calif.
Mosburg, Lewis G., Wewoka, Okla.
Moulton, Gail F., Urbana, Ill.
Munn, Malcolm J., Tulsa, Okla.
Murphy, Paul C., Tulsa, Okla.
Myers, John C., Houston, Tex.
Nelson, Walter S., Denver, Colo.
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Nesbit, Millard F., Santa Barbara, Chihuahua, Mexico
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Newby, Jerry B., Bradford, Pa.
Nickell, C. O., Wichita Falls, Tex.
Nightingale, William T., Casper, Wyo.
Nisbet, John M., Bartlesville, Okla.
Noble, Homer A., Houston, Tex.
North, Lloyd, Houston, Tex.
Norton, George H., Coleman, Tex.
Notestein, Frank B., Wooster, Ohio
Nowlan, Harry H., Tulsa, Okla.
Officer, Herbert G., Tulsa, Okla.
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Ott, Emil, San Angelo, Tex.
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Parks, Emerson M , Denver, Colo.
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Paxson, Roland B., Houston, Tex.
Peabody, Harlan W., Tulsa, Okla.
Penny, Frederick W., Roumania
Pepperberg, Leon J., Dallas, Tex.
Perini, Vincent C., Jr., Cisco, Tex.
Perkins, Joseph M., Eastland, Tex.
Perrine, Irving, Oklahoma City, Okla.
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Storm, Willis, Dallas, Tex.
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Thompson, Robert R., Fort Worth, Tex.
Thompson, Sheridan A., Houston, Tex.
Thompson, Wallace C., Wichita Falls, Tex.
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Fipps, E. L., Tulsa, Okla.
Fitzgerald, James, Jr., Bartlesville, Okla.
Fortier, Leo R., Wichita, Kans.
Fralich, Charles E., Ponca City, Okla.
Francis, George A., Cisco, Tex.
Gahring, William R., Norman, Okla.
Gallagher, William G., Fort Collins, Colo.
Giddings, Harvard, Eastland, Tex.
Giles, John M., Tulsa, Okla.
Grinsfelder, Sam, Fort Collins, Colo.
Gunby, Merle F., Laredo, Tex.
Hagy, Lawrence R., Oklahoma City, Okla.
Hanson, Edwin V., Houston, Tex.
Harlton, Bruce H., Tulsa, Okla.
Hawley, Gladys W., Tulsa, Okla.
Hazzard, Roy T., Shreveport, La.
Hedley, J. David, Amarillo, Tex.
Henderson, W. D., Tulsa, Okla.
Hockman, James N., San Angelo, Tex.
Holland, Paul O., Fort Worth, Tex.
Hoover, William B., Amarillo, Tex.
Horkey, William E., Tulsa, Okla.
Howendobler, John L., Tulsa, Okla.
Hoyle, Charles R., Shawnee, Okla.
Hunt, Raymond S., Bartlesville, Okla.
Isenberger, N. P., Amarillo, Tex.
Jay, Stanley E., San Angelo, Tex.
Jones, Albert L., Fowlerton, Tex.
Jones, Roy D., Okmulgee, Okla.
Keenan, J. Kenneth, Tulsa, Okla.
Kelly, Donald, Crowell, Tex.
Kennedy, John B., Oklahoma City, Okla.
Kent, Hugh McElwee, Tulsa, Okla.
Kerns, Floyd G., Oklahoma City, Okla.
Kisling, James W., Jr., Enid, Okla.
Kister, Herbert H., Wichita Falls, Tex.
Kittredge, M. B., Tulsa, Okla.
Klinger, Edgar D., Bartlesville, Okla.
Knebel, G. Moses, Mart, Tex.
Kornfeld, Moses M., Dallas, Tex.
Koschmann, A. H., Stillwater, Okla.
LaRue, James E., Houston, Tex.
Laughlin, R. W., Holdenville, Okla.
Lee, Huylar W., Cisco, Tex.
Livingston, Noyes B., Fort Worth, Tex.
Longnecker, Oscar M., Jr., Houston, Tex.
Loskamp, Alvin P., Cisco, Tex.
MacNaughton, Lewis W., Lufkin, Tex.
Markley, Elmer A., Tulsa, Okla.
Matson, Martin, Bartlesville, Okla.
Maucini, Joseph J., Amarillo, Tex.
McClellan, Hugh W., Bartlesville, Okla.
McClure, Joseph D., Wichita, Kan.
McCullough, Edward H., Wichita, Kan.
McDonald, O. G., Tulsa, Okla.
McDonald, Worth W., El Dorado, Ark.
McFarland, Paul W., Laredo, Tex.
McLaughlin, Homer C., Duncan, Okla.
McLaughlin, Maurice T., Wichita Falls, Tex.
McNeeley, Robert, Ponca City, Okla.
Meland, Norman, Oklahoma City, Okla.
Merry, Edward T., Cisco, Tex.
Meyer, Arthur M., Ardmore, Okla.
Millar, John E., Tulsa, Okla.
Miller, Carroll C., Mirando City, Tex.
Miller, Edward F., Denver, Colo.
Mohr, Clifford L., San Angelo, Tex.
Morris, Walter W., Henryetta, Okla.
Morse, Paul F., Houston, Tex.
Munson, Herbert E., Pittsburgh, Kan.
Murphy, Earle N., Tulsa, Okla.
Newman, Thomas F., Abilene, Tex.
Noble, Earl B., Los Angeles, Calif.
Noble, Gilbert W., Coffeyville, Kan.
Nolte, Wm. J., Wichita Falls, Tex.
Nordman, O. E., Tulsa, Okla.
Obering, Ernest A., Shreveport, La.
Oborne, Harry W., Colorado Springs, Colo.
Oles, L. M., Amarillo, Tex.
Owen, Herman J., Okemah, Okla.
Oyster, Frank A., Abilene, Tex.
Packard, Sidney A., Oklahoma City, Okla.
Palmer, R. H., Seattle, Wash.

Park, Hazel, Bartlesville, Okla.
Paschal, Elisha A., Oklahoma City, Okla.
Pease, Cecil C., Topeka, Kan.
Pepper, James F., Amarillo, Tex.
Pettigrew, Virgil, Wichita Falls, Tex.
Philbrick, E. P., Fort Worth, Tex.
Pishney, Charles H., Tulsa, Okla.
Ports, Waldo W., Wichita Falls, Tex.
Potter, Nelson B., Tulsa, Okla.
Pratt, Ernest S., Ponca City, Okla.
Purzer, Joseph, Tulsa, Okla.
Reed, Edwin M., Tulsa, Okla.
Reed, Lyman C., Houston, Tex.
Reid, Robert P., Bartlesville, Okla.
Richards, A. Howard, Ponca City, Okla.
Ridgway, Bertrand S., Independence, Kan.
Rife, Byron, Abilene, Tex.
Roberts, Louis C., Jr., Amarillo, Tex.
Robertson, Parker A., Tampico, Mexico
Robinson, B. F., Tulsa, Okla.
Rohrbach, G. Lynn, Tulsa, Okla.
Roop, Charles W., Bartlesville, Okla.
Rutledge, Richard B., Winfield, Kan.
Ryniker, Charles, Tulsa, Okla.
Samuell, J. Howard, Coleman, Tex.
Schlosser, Paul A., San Angelo, Tex.
Schneider, G. W., Shreveport, La.
Schnurr, Cornelius, Amarillo, Tex.
Schouten, Franklin H., San Angelo, Tex.
Scruggs, Maurice D., Ponca City, Okla.
Seitz, J. R., Billings, Okla.
Shamblin, W. E., Holdenville, Okla.
Smoots, John P., Shreveport, La.
Solliday, A. L., Wichita Falls, Tex.
Spangler, Grant W., Shawnee, Okla.
Splane, Howard, Tulsa, Okla.
Stafford, Clare J., Tulsa, Okla.
Staggs, Olan B., Tulsa, Okla.
Stangle, Frank Jr., Fort Worth, Tex.
Stein, Ira H., Ponca City, Okla.
Striker, Arthur F., Roswell, N.Mex.
Swiger, Rual B., Abilene, Tex.
Tandy, J. Hiram, Tulsa, Okla.
Taylor, Cyril B., Abilene, Tex.
Thompson, T. C., Abilene, Tex.
Thomson, B. E., Fort Worth, Tex.
Thornburgh, H. R., San Angelo, Tex.
Torrey, Paul, Bradford, Pa.
Tygrett, H. V., Dallas, Tex.
Tyson, Alfred K., Maysfield, Tex.
Van Dall, John E., Seminole, Okla.
Vanderpool, Harold C., Shreveport, La.
Van Weelden, Arie, Dallas, Tex.
Vernon, Jess, Shawnee, Okla.
Vorbe, Georges, Thurber, Tex.
Waters, James A., Dallas, Tex.
Watson, Cresap P., New York, N.Y.
Weaver, George A., Mexia, Tex.
Weeks, Herbert J., Dallas, Tex.
Wender, W. G., Cisco, Tex.
Whitcomb, Bruce, Fort Worth, Tex.
White, Stanley B., Hamilton, Kan.
Whitney, Paul A., Tulsa, Okla.
Whitworth, Virgil L., Dallas, Tex.
Wiest, Frank C., Tulsa, Okla.
Williams, Garnett A., Tulsa, Okla.
Williamson, Thomas S., Norman, Okla.
Wolf, Albert G., Houston, Tex.
Woods, E. Hazen, Tulsa, Okla.
Word, Ernest B., Covington, Okla.
Wosk, L. David, Tulsa, Okla.
Wyman, Everett A., Wichita Falls, Tex.
Wynn, Warren H., Tulsa, Okla.
Yeager, Lloyd I., Bartlesville, Okla.
Young, Claude T., Oxford, Kan.
Young, Karl Etienne, Houston, Tex.
Zavoicc, Basil B., Enid, Okla.
Zoller, Henry E., Braman, Okla.

Report of the President

According to the precedent established by my predecessors, the important progress of the Association will be briefly reviewed in this report.

At the last annual meeting of the Association in Dallas, Texas, four entirely inexperienced officers were elected to the Executive Committee; inexperienced in not having been closely in touch with the workings of the Executive Committee during recent years. This is the first time since the inception of the Association that such a large percentage of the Executive Committee members have been unfamiliar with the details of the preceding work. This is mentioned not as an excuse for what we have done or what we have left

undone, but as a caution to the Association against such procedure, unless some educational means is afforded to keep a fairly large and representative group of members constantly well informed on the workings of the Association.

A resolution passed by the Dallas Convention directed the Executive Committee to employ a full-time, salaried, secretary-editor and to establish headquarters for the Association whenever this could be done without an increase in membership dues. According to the suggestion of several candidate cities in offering financial assistance to accomplish this aim, the Executive Committee invited the prospective localities for headquarters to underwrite the Association in any deficit which might occur during the first few years of such an experiment. We did not ask for outright donations, as it was thought wise to have the Association stand upon its own resources if at all possible. In response to this invitation, five cities individually agreed to underwrite a sufficient deficit in case the selection fell to them. This automatically insured the Association the establishment of headquarters and the employment of a business manager without drawing upon the reserve fund.

A criticism which has come to my attention in this connection is that the Executive Committee was putting the headquarters proposition up to the highest bidder. Such an accusation is entirely unwarranted, as shown by the fact that five different cities agreed to underwrite a sufficient deficit. Tulsa, Oklahoma, was selected as headquarters because of its important relation to the majority of the membership. Furthermore, we have passed the first year of this headquarters-business manager experiment with a substantial credit balance and the Association has not received any cash assistance.

In view of this condition, together with the fact that the business manager has become established in his routine work, the Executive Committee has relieved Tulsa of any cash guaranty. This automatically frees the incoming Executive Committee of all agreements or promises we have made or received for the Association concerning the matter of headquarters. From our experience of the past year, we do not think that the Association will have any deficit by this arrangement if the proper management is pursued. Moreover, the year is yet young and the incoming Executive Committee will have ample opportunity to improve upon our work in plenty of time to avoid any arising possibility of a shortage.

Mr. J. P. D. Hull, formerly chief geologist of the Louisiana Oil Refining Corporation, was selected business manager for the Association. He began this work about July 15 and moved all the records of the Association to Tulsa. Since that time the active operation of the Association's business has been functioning from his office here. Mr. Hull's first instructions from the Executive Committee were to familiarize himself with the work formerly done by Dr. Moore and Dr. Decker and to push this work with all expediency. This is probably a greater task than most of you realize, and Mr. Hull has continued their work effectively. The *Bulletin* has been published without delay according to its high standards of former years. Largely due to Mr. Hull's economy and management, the Association has changed the scenes of operation for two of the most important phases of its work and finished the year in a healthy financial condition. Gentlemen, this speaks for itself.

The Executive Committee, with the help of Mr. Max W. Ball and Mr. James R. Jones, has uncovered the unfinished business of incorporating the Association properly, which was started in 1924. The same will be completed, if possible, before the expiration of our term of office.

We have given much time and thought to ways and means for the betterment of the

Association regarding matters such as an endowment fund, methods of balloting, and possible improvements to the Constitution and By-Laws. A number of suggestions have been placed before your General Committee of representative members several weeks prior to this Convention. This was done so that a majority of you, before coming to this meeting, could have the opportunity to know some of the problems the Executive Committee considered worthy of discussion. No doubt, during this Convention, the General Committee will present resolutions and suggestions on the more important of these topics for your consideration.

The usual appointments expected of the president have been carried out to the best of my ability and knowledge at the time. Mr. W. E. Wrather, one of our representatives to the National Research Council, retires in June, 1927. According to the rules of the National Research Council, he is not eligible to reappointment, since he has served on the Council for three years. His successor must be named before April 20. Therefore, I have appointed Dr. Sidney Powers as representative of the American Association of Petroleum Geologists to the National Research Council for the period from June, 1927, to June, 1930.

During the year, the Association joined the American Institute of Mining Engineers, the American Mining Congress, and the Silver Producers Association in a western convention at Denver, Colorado. The mid-year meeting of the Association was held in New York City during November, 1926. It is unnecessary to discuss the worth-while character of these meetings. A large portion of the membership is familiar with the results and many of the excellent papers presented are now appearing in our *Bulletin*. At the invitation of the American Petroleum Institute, the Association presented a half-day program during the annual convention of the Institute in December.

We have heard a great deal about research in petroleum geology during the last few years. Many of our members have been anxious that the Association, as a body, accomplish something definite along this line. Research can only be promulgated by an accumulation of a great many well-correlated and catalogued facts followed by a careful, scientific analysis of them. Now the Executive Committee realized that the Association did not have the facilities to carry on systematic compilation or experimental work. Furthermore, it is hardly worth while to attempt such work in a disorganized manner, and work of this nature by individuals or small groups is handicapped by the limitation of known facts. On the other hand, the Executive Committee considered that there are many facts available for the records of the Association by the summation of knowledge held individually throughout its ranks. Therefore we have suggested a definite move to present these facts to the Association by a series of symposiums on the more important problems of petroleum geology. The work of the future executive committees will be to assemble more facts on other vital problems. Finally, when sufficient facts are accumulated, the Association should turn its attention to the proper analysis of these facts.

It is natural that each individual writer upon single phases of these problems should suggest his own interpretation of the particular condition, but the vital part of this united program is to obtain the most comprehensive summary of all the known facts which can later be subjected to a systematic correlation and interpretation.

Since work of this nature is so important to the Association, we have urged that oral presentation during conventions this year be limited, so far as possible, to the particular symposium under discussion. The Association expects to receive all papers and to publish all worth-while articles on any type of geology with reference to petroleum. For that reason we have inaugurated the bulletin-board method of presentation. Maps and manu-

scripts on any number of papers which might not fit in with the particular theme under discussion can be presented to the Association at large on bulletin boards. Members can read and study these data at their leisure. We are sure that the members of the Association will be glad to co-operate in this program. Every member with the interest of Association research at heart should willingly submit to the direction of the program committees and be governed by their ideas of oral presentation. The work of the future program committees is extremely important. They should study the situation thoroughly and select the most important problems to bring out the desired facts. The Program Committee of this Tulsa meeting has admirably co-operated with this idea and it is hoped that this convention will be successful in setting forth a comprehensive résumé of information on oil-field structure.

The work on the Executive Committee this year has been very enjoyable in spite of its occasional strenuous character. I wish to thank the other members of the Executive Committee, as well as the regional directors and regional editors, for their heartiest co-operation at all times. The work of the committees for the Denver Joint Meeting and the New York Regional Meeting is especially worthy of praise. The individuals of the Association who assisted in the American Petroleum Institute program are also deserving of thanks. The personnel of the Tulsa Geological Society and many individuals and oil companies of Tulsa are to be commended for their co-operation with the Association work at headquarters and also for the excellent manner in which they have made this meeting so promising. I should also like to thank the individuals in the Association who have presented criticisms and suggestions to the Executive Committee in writing. In spite of the fact that it has been impossible for the Executive Committee to accept and act upon all suggestions received, nevertheless, we appreciate the thoughtful and sincere consideration these members have given the welfare of the Association. Personally, I appreciate more than I can tell you the honor and confidence you have expressed in naming me your chief executive during the last year, and I assure you that I have endeavored to conduct myself with the fairness and dignity which the responsibility imposes.

ALEX W. MCCOY, *President*

REPORT OF THE SECRETARY

The following report of the secretary has been prepared in tabulated form for ready comparison with last year's report, as published on pages 541 and 542, Vol. 10, No. 5, of the *Bulletin* (May, 1926.)

Although the increase in membership over last year is 85 less than last year's increase over the preceding year, it is apparent that a growth of 166 members for the year is very satisfactory, and the fact that we now have 181 applications for membership is additional evidence of a successful year; however, the number of members in arrears for dues during previous years is entirely too large. There are ten men in arrears for 1925 and 1926, and forty-seven in arrears for 1926 alone. According to Section 2 of the By-laws, these men should be dropped from membership. All of the men in arrears have been notified three times each year of their delinquency, and in many cases they have failed to reply. The total amount due the Association from members in arrears is $1,506.00.

The geographic distribution of the members is shown in a report on pages 317 and 318, Vol. 11, No. 3, of the *Bulletin* (March, 1927). A list of our 1,670 members (honorary, 5; active, 1,146; associate 519) is given on pages 318–51 of Vol. 11, No. 3, of the *Bulletin*.

Membership of the Association:

Number of members May 19, 1917 (first published list)		94
Number of members February 15, 1918		176
Number of members March 15, 1919		210
Number of members March 18, 1920		392
Number of members March 15, 1921		621
Number of members March 8, 1922		767
Number of members March 20, 1923		901
Number of members March 20, 1924		1,080
Number of members March 21, 1925		1,253
Number of members March 20, 1926		1,504
Number of honorary members March 1, 1927	5	
Number of active members March 1, 1927	1,146	
Number of associate members March 1, 1927	519	
Total number of members, March 1, 1927		1,670
Increase in membership since March 20, 1926		166
Applicants elected, dues unpaid	19	
Applications approved for publication	73	
Recent applications	89	
Total applications on hand		181
Number of members withdrawn	9	
Number of members dropped	13	
Number of members died	11	
Number of members in arrears, 1925–26–27 dues	10	
Number of members in arrears, 1926–27 dues	48	
Active members in arrears, 1927 dues	350	
Associate members in arrears, 1927 dues	170	
Total number of members in arrears, 1927 dues		578
Members paid dues in advance, January 1, 1927		278

Distribution of publications:

1. Subscriptions		
Libraries (domestic, 91; foreign, 15)	106	
Companies (domestic, 52; foreign, 31)	83	
Individuals (domestic, 60; foreign, 19)	79	
Total subscriptions		268
Increase in number of subscriptions		26
Subscriptions paid in advance of January 1, 1927		43
2. Exchange, etc.		34

F. L. Aurin, *Secretary*

Report of the Treasurer

The accompanying report of the treasurer with the Auditor's statement is made up in forms similar to last year's report for the purpose of ready comparison of the items. Probably the outstanding feature of this part of the report as shown is "Summary for Period." (1) Net increase in cash, $2,870.04. (2) Increase in invested money $330.42. (3) Total gain for the period, $3,201.36. (4) Cash in bank $12,080.12. (5) Total cash and securities on hand March 10, 1927, $29,810.54.

Explanation of item of Cash in Bank, $12,080.12: This figure takes into consideration a cash donation of $1,000 paid to the Paleontological Group, which, if it had not been made, would have given us a cash surplus of $13,080.12, or a total net gain for the period of $4,201.36.

A financial statement, as of December 31, 1926, was also prepared, which showed a 1926 surplus of $909.26. This figure does not include any 1927 dues and subscriptions paid during the year of 1926. In spite of the burden of establishing headquarters, the Association has weathered both the calendar and the fiscal year with a surplus in the bank. The auditor's report is as follows:

Auditor's Statement

1715 East Thirteenth St., Tulsa, Oklahoma
March 12, 1927

Mr. J. P. D. Hull, Business Manager,
American Association of Petroleum Geologists
Tulsa, Oklahoma

Dear Sir:

Pursuant to request I have audited the accounts of the American Association of Petroleum Geologists for the period March 18, 1926, to March 10, 1927, and submit herewith statement of receipts and disbursements for the period, a schedule of securities on hand at the end of the period, and a schedule of office furniture and equipment purchased during the period, also a summary showing the net results.

The cash on hand at March 18, 1926, and receipts for the period, exceed the disbursements by $12,080.12, which correspond with the bank's statements: the securities amounting to $17,400.00 were inspected and counted, and the savings account amounting to $330.42 was verified.

The accounts have been accurately kept and the results indicate that the Association is well managed.

The utmost courtesy was extended and every assistance was given during the audit.

I certify that, in my opinion, the statement and schedules submitted with this report present the true condition of the Association at March 10, 1927.

Yours very truly,

(*Signed*) W. O. Thompson
Certified Public Accountant

STATEMENT OF RECEIPTS AND DISBURSEMENTS

MARCH 18, 1926, TO MARCH 10, 1927

Cash in Banks at March 18, 1926 (Auditor's Report)			$ 9,209.18
RECEIPTS FOR PERIOD:			
Associate dues	$ 4,388.00		
Active membership dues	16,728.75		
Total membership dues		$21,116.75	
From Bulletin:			
Subscriptions	3,066.74		
Sale bound copies	2,749.05		
Sale back numbers	2,602.07		
Advertising	1,586.70		
Separates	4.00		
Total receipts from *Bulletin*		10,008.56	
Sale Salt Dome Volumes		2,725.17	
Other:			
Interest earned on investments		782.09	
Miscellaneous		118.69	
Total receipts for period			34,751.26
Total funds handled for period			$43,960.44
DISBURSEMENTS FOR PERIOD:			
Bulletin:			
Editor's salary	$ 150.00		
Editor's postage, supplies, telegrams	47.51		
Chicago editorial secretary	1,755.00		
Chicago editorial expense	54.95		
Advertising manager expense	13.00		
Total editorial expense		$ 2,020.46	
Printing (University of Chicago Press):			
Printing Volume 10 No. 3	1,399.51		
10 No. 4	821.15		
10 No. 5	865.66		
10 No. 6	1,015.87		
10 No. 7	906.85		
10 No. 8	717.95		
10 No. 9	905.07		
10 No. 10	980.87		
10 No. 11	1,380.99		
10 No. 12	1,505.57		
11 No. 1	1,065.37		
11 No. 2	1,290.72		
Total printing regular issues		12,855.58	
Carried Forward		$14,876.04	

Brought Forward		$14,876.04
Other expenses:		
Stencil corrections and mailing	1,021.27	
Cloth binding	640.00	
Printing separates	653.69	
Back numbers purchased from members	45.00	
Storage, freight, and drayage	47.08	
Miscellaneous	26.97	
Total other expense		2,434.01
Total *Bulletin* expense		$17,310.05
Salt Dome Volumes:		
Printing	1,912.65	
Editorial work	114.75	
Miscellaneous	168.69	
Total Salt Dome expense		2,196.09
Total publication expense		$19,506.14
Contribution to Paleontological Group		1,000.00
General office expense:		
Secretary's salary	165.00	
Manager's salary	4,687.50	
Clerical salaries	2,270.00	
Printing	702.34	
Postage	515.93	
Supplies:		
Office furniture and equipment	749.02	
Other	131.18	
Exchange and refunds	71.57	
Telegraph and telephone	229.93	
Freight, express and drayage	150.99	
Total office expense		9,673.46
Dallas meeting expense:		
Printing and postage (notices, etc.)	455.53	
Hotel and traveling expense	121.69	
Clerical help	47.50	
Express and drayage	12.27	
Total meeting expense		636.99
Carried Forward		$30,816.59

Brought Forward		$30,816.59	
Other expense:			
Executive expense	$ 111.70		
Traveling expense	693.58		
Miscellaneous expense	258.45		
Total other expense		1,063.73	
			31,880.32
UNEXPENDED BALANCE IN BANK			$12,080.12
Balance as per Bank Statement			13,444.23
Less: Outstanding checks			
77 University of Chicago Press		1,290.72	
78 Daisy W. Heath		179.25	
79 Daisy W. Heath		39.00	
80 Daisy W. Heath		6.25	
Total outstanding checks			1,515.22
Balance, Principal Account, as per books			11,929.01
Petty cash balance, as per books			151.11
			$12,080.12

SUMMARY FOR PERIOD MARCH 18, 1926, TO MARCH 10, 1927

Total receipts for period	$34,751.26	
Total disbursements for period	31,880.32	
Net increase in cash for period	2,870.94	
Increase in cash through sale of Wilson & Co. Bond and exchange in California Nevada Electric Co. Bonds	330.42	
Total gain for period	3,201.36	
Cash and securities on hand March 18, 1926	26,609.18	
Cash and Securities on hand March 10, 1927		$29,810.54
Securities on hand March 10, 1927 (as per schedule)	17,400.00	
Savings account, March 10, 1927	330.42	
Cash in bank March 10, 1927	12,080.12	
Cash and securities on hand March 10, 1927		29,810.54

Schedule of interest-bearing bonds and securities, March 10, 1927:

	Cost	
United States Treasury Certificates	$ 4,100.00	(Par 5,000.00)
Wyoming Farm Loan	800.00	
Anaconda Copper Mining Co. Bond (6½%)	1,000.00	
California Nevada Electric Co. Bonds (5%)	6,000.00	
Pondera County Refunding Bonds (5½%)	1,000.00	
Imperial Japanese Government Bond (6½%)	500.00	
St. Louis and San Francisco Rwy. Bond (6%)	500.00	
United States Rubber Co. Bond (5%)	1,000.00	
Hardin County Texas Road Bond (5%)	1,000.00	
Northern States Power Co. (6%)	1,500.00	
	$17,400.00	
Savings account in National Bank of Commerce	330.42	
	$17,730.42	

OFFICE FURNITURE AND EQUIPMENT PURCHASED DURING THE PERIOD MARCH 18, 1926, TO MARCH 10, 1927

Date 1926		Article	
April	2	3 steel filing cases	$260.00
July	16	1 table, oak	35.00
	16	1 swivel chair, oak	10.00
	16	3 chairs	5.00
	16	1 costumer	5.00
	16	2 waste baskets	2.00
	16	1 cuspidor with mat	1.00
	16	1 roll top desk	
	16	1 glass top table	75.00
	19	1 nine inch oscillating fan	
	19	1 twelve inch oscillating fan	36.67
July	26	1 cash box	.96
	26	1 Sengbusch inkwell	4.20
	27	10 ft. extension cord	1.05
	30	1 office chair	9.00
	30	1 crescent postage scale	1.76
	30	1 twenty-pound parcel-post scale	3.20
August	1	1 bevel plate glass top	13.50
	10	transfer cases	3.68
	10	2 No. 5 Underwood typewriters	144.50
Oct.	7	1 swivel chair, oak	8.00
	7	1 52-inch table, oak	30.00
	12	1 Weis swinging desk	6.00
	27	1 gas heater	8.00
Dec.	29	1 gas heater	12.00
1927 Jan.	20	1 Burroughs adding machine	73.50
			$749.02

F. L. AURIN, *Treasurer*

REPORT OF THE EDITOR

When I assumed the editorial duties a year ago it was expected that a business manager, who would serve as acting editor, would be appointed at an early date. Circumstances, however, delayed the appointment of the business manager and his assumption of editorial duties until late in July. During the intervening four months all of the editorial work was carried on by me with the assistance of the regional associate editors. This experience gave me a lively appreciation of the amount of time and effort that is required to prepare each issue of the *Bulletin* and to see it through the press. I had not realized, and I doubt if the Association as a whole has realized, how much of time and energy your former editor, Dr. Moore, has contributed in bringing the *Bulletin* up to the high standard at which he left it. The time had certainly come for the organization of the editorial work on other than a practically gratuitous basis.

Since the first of August Mr. Hull, the newly appointed business manager, has taken over the active editorial work, in which he had been ably assisted by the regional associate editors. To the initiative of Mr. Hull and to certain of the associate editors we are indebted for a number of suggestions which have been incorporated in the *Bulletin*.

During the latter half of the year your elective editor has been active only in an advisory capacity and as a member of the executive committee responsible for editorial work and policy. Papers offered for the *Bulletin* which are undoubtedly acceptable for publication are handled entirely by Mr. Hull. Only papers about whose acceptance or modification there may be some question are now referred to the elective editor.

No major changes in the *Bulletin* or in editorial policy have been made. Minor changes in the make-up of the *Bulletin*, such as the printing of the table of contents on the cover, the use of smaller type, lighter paper, and a greater width of printing on the page, have been made. The latter changes were made to conserve space and to accommodate the increasing amount of material offered for publication in the *Bulletin*.

A change which is designed to increase the usefulness of the *Bulletin* for field reference is the commencing of each major article on the right-hand page, so that the *Bulletin* may be separated into its component papers without mutilating any of them. This makes it possible to separate and file topically the papers of the current numbers while keeping the annual bound volumes for permanent reference.

During the past year an effort was made to give a wider distribution to the Salt Dome volume. This has met with such success that the volume is now in the clear financially.

A separate volume made up of the papers on "Continental Drift" presented at the New York meeting is in preparation. It includes fifteen papers and will be a book of 200 to 250 pages which it is proposed to publish in the same form as the Salt Dome volume. The local committee of the New York meeting has arranged to finance its publication.

The papers of the symposium on "Relation of Structure to Petroleum Accumulation in Oil Fields," which forms the principal topic of this meeting, will also, according to present plans, be published as one or more separate volumes. The type for such of these papers as may appear in the *Bulletin* is being held for the separate volume.

A topical index of the *Bulletin* from its beginning through 1926 is now in preparation and will be issued soon.

The growth of the Association has been so rapid and the number of valuable papers presented at its meetings and offered for publication in the *Bulletin* has become so great that editorial selection, and in some instances condensation, has become necessary. Not

only intrinsic merit, but also the interests of the Association as a whole and its policy as to the function of the *Bulletin*, as conceived by the editors, must guide such selections or condensations.

In one respect authors can assist materially in lowering the cost of the *Bulletin* and making it more attractive. I refer to the proper planning of illustrations. Folded inserts are costly, bothersome, and unattractive. In many instances which have come to my attention these inserts could have been avoided to the advantage of all if the author had designed his illustrations in such shape and proportions that they could be reduced to fit the *Bulletin* page. Attention to such details on the part of the authors not only simplifies editorial work and reduces costs, but also makes the paper more attractive and more of a credit to the author.

The science of petroleum geology is still young. The problems already solved are few in comparison with those remaining to be solved. The *Bulletin* is a record of progress and of the source material upon which further progress must be based, and also a forum for the presentation of working hypotheses and theories which should and do stimulate further search for facts and, finally, further progress. The *Bulletin* is the public expression of the work of the Association, and as such deserves the best thought of all connected with it in any capacity, whether as authors in presenting their material in the best possible form or as editors in maintaining and raising the high standards already set.

John L. Rich, *Editor*

BUSINESS MEETING

As a matter of unfinished business the following resolution was proposed by the Business Committee and passed by the Association in business meeting, March 25, 1927:

"Whereas the property and effects of the unincorporated organization known as the American Association of Petroleum Geologists have never been assigned to the corporate body of the same name, be it resolved that this assembly, as of the incorporated body, hereby directs Max W. Ball and Chas. E. Decker, respectively, president and secretary of the unincorporated organization as of April 15, 1924, to assign and convey all properties and effects of the unincorporated association to the corporate body."

The following recommendations of the Business Committee were adopted by the Association:

The Executive Committee is hereby instructed to prepare and submit to letter ballot an amendment to the Constitution essentially as follows:

Amend Article IV, Section 1, by striking out the words "a vice-president, a secretary-treasurer, and an editor-in-chief," and substitute therefor the words "a first vice-president, a second vice-president in charge of finances, and a third vice-president in charge of editorial work."

Amend Article IV, Section 2, by adding the words, "By written ballot deposited in a locked ballot box by those active members present at the annual meeting who have paid their current dues and are otherwise qualified under the constitution."

Amend Article III, Section 2, by adding the following: "The executive committee shall advance from associate to full membership those associates who have, subsequent to election, fulfilled the requirements for full membership, without the formality of application for such change."

The Business Committee recommends that the By-Laws of the Association be and are hereby amended as follows:

Amend Section 1 by changing "$8.00" to "$10.00."

Amend Section 2 to read: "Any member who shall fail to pay his regular annual dues for a period of one year may be dropped from membership by a vote of the executive committee, but may later apply for membership under the regular rules, if desired."

Add a new section to provide for a General Business Committee to be elected by members of various districts in local meetings (districts to be decided upon by the Executive Committee); number of delegates elected from each district to be determined by number of full members residing in said district; term of office to extend over three-year period, one-third of the members retiring each year; in case districts fail to elect representatives, the same to be elected by the Executive Committee thirty days before the Annual Meeting. This General Business Committee to act as a council for the Association and as an Advisory Board to the Executive Committee.

The Business Committee, F. W. DeWolf, *chairman*
F. L. Aurin, *secretary*

C. R. McCollom
E. F. Davis
Hoyt S. Gale
George C. Gester
Max W. Ball
Thomas S. Harrison
Charles M. Rath
Marvin Lee
Charles E. Straub
C. Max Bauer
J. V. Howell
H. B. Fuqua
L. E. Trout
J. Elmer Thomas
Luther H. White
Arthur F. Truex
James H. Gardner
M. M. Valerius
Robert H. Wood
W. C. Spooner
John S. Ivy
Wallace E. Pratt
Alexander Deussen
John R. Suman
W. E. Wrather
Leon J. Pepperberg
Glen M. Ruby
J. W. Beede
George E. Burton
Irving Perrine
Roswell H. Johnson
Kenneth C. Heald
W. T. Thom, Jr.
E. DeGolyer
Fred H. Kay
Walter M. Small
John L. Rich

Report of the Ballot Committee

The ballot committee reports as follows on the result of their tally:

For president, G. C. Gester, no contest

For vice-president	Luther H. White	267
	C. Max Bauer	136
For secretary-treasurer	David Donoghue	262
	Marvin Lee	142
For editor	John L. Rich	165
	Wilbur A. Nelson	123
	L. C. Snider	112

(*Signed*) Roy R. Morse
Ed. Bloesch
J. V. Howell

Report of the Audit Committee

The audit committee reports that it has examined and approved the certified account and the financial statement of the business manager, as it found the report to be in proper form and order. The committee considers it to be an excellent report.

W. B. Wilson, *chairman*
R. H. Johnson
J. Elmer Thomas

Report of the Resolutions Committee

Be it resolved, that the American Association of Petroleum Geologists, assembled in annual meeting, extend to the Tulsa Chamber of Commerce, the Ladies of Tulsa, the Tulsa Geological Society, and its most excellent committees, and all those who have made this meeting the wonderful success it has been, most cordial appreciation for their untiring zeal and earnest efforts in behalf of this Association.

Be it further resolved, that a copy of these resolutions be spread on the minutes of this meeting.

Irving Perrine
Luther White
F. B. Plummer

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AT HOME AND ABROAD

CURRENT NEWS AND PERSONEL ITEMS OF THE PROFESSION

Clayton H. Eaton has moved from San Antonio, Texas, to 1233 West 30th St., Oklahoma City, Oklahoma.

Francis de Loys of Los Angeles, California, is now engaged in a special study of the possibilities of northern Iraq for the Turkish Petroleum Company, Ltd., of London.

Roy L. Beckelhymer, of the Phillips Petroleum Company, has moved from Camden, Arkansas, to 625 Slattery Building, Shreveport, Louisiana.

L. S. Harlowe, chief geologist for the Louisiana Oil Refining Corporation at Shreveport, spent about two weeks at his home in Indiana last March.

Henry Schneider, geologist for the Dixie Oil Company, Slattery Building, Shreveport, Louisiana, suffered an attack of influenza bordering on pneumonia last March.

Raymond F. Baker, chief geologist of the Texas Company, Houston, Texas, made a business trip to Shreveport in March.

A. H. Noble is now with Sarawak Oilfields, Ltd., Miri, Sarawak, via Singapore.

H. Smith Clark has resigned his position in charge of geological work in the San Angelo territory for the Marland Oil Company of Texas to take up similar work with the Sinclair Oil and Gas Company.

Henry L. Hummel, chief geologist for the White Eagle Oil and Refining Company, has moved his headquarters from Wichita, Kansas, to Fort Worth, Texas.

J. C. Templeton, of the firm of Templeton & McCarthy, Houston, has been in charge of torsion-balance surveys in Mexico for the Mexican-Sinclair Corporation. Much of this work was in swamp and jungle territory.

The new officers of the New York Petroleum Club are William B. Heroy, chairman, Edwin B. Hopkins and Warren A. Sinsheimer, vice-chairmen, and A. C. Hunter, secretary.

Dr. and Mrs. Edward Bloesch, 420 West Eleventh Street, Tulsa, announce the birth of a daughter, Margaret Verena, on March 8, 1927.

The Fort Worth Geological Society gave a dinner at the Fort Worth Club, March 14, in honor of the retiring president, J. H. Jenkins, vice-president of the Tidal Oil Company. J. Elmer Thomas is the new president of the society. David Donoghue read a paper on the Desdemona field.

Chester W. Washburne is now situated at 27 William Street, New York City, after returning from two years of exploration in New Zealand and Australia.

F. W. Tappolet, geologist with the Sun Oil Company at San Antonio the past three years, accepted a position with the Royal Dutch Shell Company in Mexico last March.

George C. Matson, vice-president and secretary of the Schermerhorn Oil Company of Tulsa, has moved his office to 638 Kennedy Building.

The Ninth Field Conference under the auspices of the Oklahoma Geological Survey, near Ada, was held on February 21, 22, and 23, 1927. Forty-five geologists participated. Typical exposures of the formations of the Arbuckle Mountains were studied, as were also the deposits of asphalt two miles west of Ada, where ledges of sandstone in the Ada formation are impregnated with asphalt, which for many years has been quarried and used for street paving.

During the past two years the Oklahoma Geological Survey, under the direction of Charles N. Gould, has held a series of field conferences in Oklahoma and adjacent states for the purpose of studying and correlating the different geological formations of the region. More than two hundred geologists have participated in these conferences. The scheduled conference in the Arbuckle Mountains and the Ardmore Basin on March 28 and 29, following the annual meeting of the American Association of Petroleum Geologists at Tulsa, included, among other points of interest, the porphyry monadnock known as East Timbered Hills, Turner Falls, Prices Falls, the asphalt mines, White Mound, Burning Mountain, Caddo Anticline, and Criner Hills. In May it is planned to hold a field conference in the Panhandle of Oklahoma, studying conditions near the Ramsey well in Cimmarron County, together with the volcanic rock on Black Mesa and the Cretaceous exposures in that area.

The West Texas Geological Society and the Bureau of Economic Geology of the University of Texas arranged a conference and excursion into the Glass Mountains of Texas, February 26 and 27. The party assembled at Alpine and disbanded at Fort Stockton. One hundred fifteen geologists participated, chiefly from Texas, including, however, some from New Mexico and Oklahoma. During the two days, selected exposures were examined representing the formations of the unequaled sections of the Permian of the Glass Mountains, totaling some 6,000 feet of sediments as well as some exposures of the Pennsylvanian and Cretaceous. The next excursion of the series will be into the Delaware and Guadalupe mountains, probably in May.

At the University of Texas, during the spring term of the present year, a course is being given in petroleum geology, participated in by the following geologists: Charles Laurence Baker, geology of the petroleum fields of Mexico, March 19–25; J. W. Beede, petroleum production from the Permian formations of West Texas, March 26—April 8; F. B. Plummer, petroleum production from the Pennsylvanian formations of Texas and origin of petroleum, April 9–22; Alexander Deussen, petroleum production from the salt domes of the Gulf Coastal Plain, April 23–29; Donald C. Barton, geophysical methods, foreign salt domes, and organization of applied geology, April 30—May 13; and W. E. Wrather, petroleum production in the Mid-Continent fields of the United States, May 14–27.

A. S. Clinkscales, consulting geologist, has moved his headquarters to 719 World Building, Tulsa. Mr. Clinkscales is opening a temporary office in Eastland, Texas.

Fred B. Ely has returned to New York after a year spent in Venezuela. Mr. Ely's address is Room 1560, 26 Broadway, New York City.

William T. Thom, Jr., geologist in charge of the fuels section of the U. S. Geological Survey, has been granted leave of absence to give courses in structural, petroleum, and coal geology at Princeton University during the term 1927–28.

E. W. SHAW went to South America last month.

V. F. MARSTERS has moved his location, for a few months, from Kansas City, Missouri, to Farmington, New Mexico, where he is engaged in geological work in the San Juan Basin. Mr. Marsters is chief geologist of the Colorado Oil Lease Syndicate.

C. G. STALEY of Socorro, New Mexico, has been promoted to the position of chief geologist of the New Mexico State Geological Department, succeeding E. H. WELLS, resigned.

President A. W. McCOY announces the appointment of SIDNEY POWERS as representative of the American Association of Petroleum Geologists on the National Research Council for the three-year term beginning July 1, 1927. Mr. Powers succeeds W. E. Wrather, whose term of office is expiring.